PROJECT MANUAL
VOLUME TWO
FEBRUARY 12, 2020

FOR THE PROJECT TITLED

OAKLAND ELEMENTARY SCHOOL
12 CLASSROOM ADDITION
CLARKSVILLE, TENNESSEE

OWNER
CLARKSVILLE / MONTGOMERY COUNTY SCHOOL SYSTEM
CLARKSVILLE, TENNESSEE

DESIGNER
RUFUS JOHNSON ASSOCIATES
1740 MEMORIAL DRIVE, SUITE 2
CLARKSVILLE, TENNESSEE 37043
(931) 647-6301
TO: All Bidders of Record

This Addendum Number One forms part of the Contract Documents and modifies the original Bidding Documents dated February 12, 2020.

This Addendum Number One is in response to the Review of Plans, #1, letter dated February 24, 2020 from the State Fire Marshal’s Office (SFM). We offer responses and revisions to the following Items 1-4 along with additional items identified in markups provided to Architect from SFM. Additionally, three other items are included unrelated to SFM comments.

**SFM Item #1:** Use the International Building Code terms for fire-resistance assemblies:

**FIRE WALL.** A fire-resistance-rated wall having protected openings, which restricts the spread of fire and extends continuously from the foundation to or through the roof, with sufficient structural stability under fire conditions to allow collapse of construction on either side without collapse of the wall. IBC Section 202 & 706.

**RESPONSE:** Please find revisions to the following sheets- LS1.02, A1.02, A1.03, A1.04, A1.06, M1.01, M2.01, E1.01, E2.00, E2.01, E3.01, P1.00, P1.01, P2.01, FP1.01.

Legend revised or added to all above referenced sheets.
Related note on sheet A1.02 is revised to read “2 Hour Fire Wall”

**SFM Item #2:** For all fire rated assemblies, provide Gypsum Association or UL assembly listing (or other) details in their entirety including design illustrations and material specifications without modification or manipulation, IBC 107.2.1, 703.3.

**RESPONSE:** The latest versions of all UL assemblies are included in their entirety in the Project Manual. Please reference Section 01 06 10 U.L. Wall Assemblies.

A reference note is added to sheet G2.01 for additional clarity.

**SFM Item #3:** Provide the following information on the Automatic Sprinkler System Design Intent site plan:

1. Show the location of the point of service for the underground sprinkler piping on the site plan. and provide a note stating “Installation of all sprinkler system piping from the point of service must be performed by a Tennessee registered sprinkler contractor.” Rule 0780-2-7-.08

**RESPONSE:** Please reference the following sheets:
C100, Utility Notes: U-15
Revised sheet C700 - note 8
P1.00 references Civil Drawings

(2) Provide details of the underground piping from the point of service to the building. Identify: the NFPA 24 6.2.11 system isolation valve location & type, underground piping material type and size, depth of bury, valve pit, trench detail, and thrust block size and location. IFC 507.2.1, NFPA 24 Chapter 4, 5, 10, and NFPA 13 Chapter 10

RESPONSE: Please reference the following sheets:
C801 and C802.
Revised sheet E3.01 – General Note F added and Tamper Switch is added at to the Post Indicator Valve (PIV).

SFM Item #4: Civil Drawings shall include the following items that pertain to the design of the private fire service main (IFC 507.2.1 and NFPA 24 4.1.3):

(1) Size and location of all water supplies and underground utilities.

RESPONSE: Please reference revised sheet C700.

(2) The following items that pertain to private fire service mains:
(a) Size, length, location, material

RESPONSE: Please reference revised sheet C700.

(b) Point of connection to the main

RESPONSE: Please reference revised sheet C700.

(c) Sprinkler system point of service. Point of service means the point immediately after the tap of the service main where water is used exclusively for fire protection purposes.

RESPONSE: Please reference revised sheet C700.

(d) Sizes, types, and locations of valves, valve indicators, regulators, meters, and valve pits.

RESPONSE: Please reference revised sheet C700.

(e) Depth at which the top of the pipe is laid below grade.

RESPONSE: Please reference Utility Trench Detail on sheet C802.

(f) Method of restraint

Additional SFM related comments addressed: Door E31A glazing to be noted as fire rated glass (FG).

RESPONSE: Please see revised sheet A2.01 which updates the glazing type on Door E31A.

Other items addressed not related to SFM comments:

1. See revised sheet E1.01. General Note E added, related to lighting controls. The intent is for the Contractor to provide a fully operational system.

2. See revised sheet E2.00. Electrical Note 4 revised, related to fire alarm system. The intent is for the Contractor to provide a fully operational system.

3. See revised sheet FP1.01. Removed note referencing Hot Box.

End of Addendum 01.

Attachments: Nineteen (19) 30"x42" sheets
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SECTION 210100

FIRE PROTECTION GENERAL PROVISIONS

PART 1 GENERAL

1.1 WORK INCLUDED

A. Provide all labor, materials, tools, and services for a complete installation of equipment and systems contained in contract documents.

B. Principal features of work included are:
   1. Fire Protection system.
   2. Seismic bracing and anchorage for equipment and piping.

1.2 RELATED WORK

A. Electrical power and interlock and control wiring and conduit.

B. Field painting of exposed pipe.

1.3 GENERAL

A. The contract documents form a guide for a complete system. Provide all items necessary to provide a complete system but not specifically mentioned, such as hangers, transitions, offsets, and drains.

B. Layouts indicated on drawings are diagrammatical only. Coordinate exact location of equipment, ductwork, and piping to eliminate conflict with other divisions. Designer reserves right to make reasonable changes in location of equipment, and piping prior to construction.

C. Should Contractor find during progress of work that in his judgment existing conditions make desirable a modification, report such item promptly to Designer for instructions. Do not make deviations from contract documents without review of Designer.

D. Supervise all work with a competent mechanic specifically qualified in fire protection work.

E. The installing sprinkler contractor shall be licensed or permitted by the state and local authority having jurisdiction to perform fire protection installations. This shall be in compliance with all applicable state and local laws.

F. Modifications to system or equipment shall be coordinated by General Contractor. Any associated increase of cost of utility service/feeds proposed by General Contractor or Subcontractor shall be the responsibility of the Contractor.
1.4 PERMITS
   A. Secure and pay for permits, licenses, and inspections for work under this Division, including water connections.

1.5 CODES
   A. Comply with all pertinent local, State, and national codes.

1.6 STANDARDS
   A. Comply with all pertinent standards. This list is provided as a convenience to the contractor and is not to be considered all inclusive.
      1. NFPA 13: Standard on automatic sprinkler systems.

1.7 SUBMITTALS
   A. Submit for review complete brochures and shop drawings for materials and equipment proposed.
      1. Brochures: Submit complete descriptions, illustrations and specification data for materials and equipment proposed. Clearly indicate proposed items when other items are shown on same sheet. Submit samples on request and/or set up for inspection. Samples will be returned to Contractor.
      2. Shop Drawings: Complete equipment, and piping systems.

1.8 PROJECT MAINTENANCE MANUALS
   A. Prior to final acceptance of project, provide Owner with bound maintenance manuals.

1.9 PROJECT TECHNICAL INSTRUCTION
   A. Prior to final inspection of project, provide technical instruction to Owner as follows:
      1. Field Instruction: Provide explanation of how systems and equipment are to operate.
      2. Field Demonstration: Demonstrate operation and routine maintenance for systems and equipment.

1.10 CONSTRUCTION RECORD DOCUMENTS
   A. Provide construction record documents. Keep at the project one set of drawings and daily record changes at the time they are made. Give drawings to Owner at project completion.

1.11 EXISTING SERVICES
   A. Maintain existing services in operation during construction. Coordinate and schedule all service interruptions with Owner.
PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Provide materials and equipment of domestic manufacturer bearing the U.L. and F.M. label when such label is available.

PART 3 EXECUTION

3.1 COORDINATION

A. Coordinate location of fire protection piping with equipment, ductwork, and other piping to eliminate conflict with other divisions.

B. Provide proper chases and openings. Place sleeves and supports prior to pouring concrete or installation of masonry.

3.2 CUTTING AND PATCHING

A. Repair or replace routine damage caused by cutting in performance of contract.

B. Correct unnecessary damage caused due to installation of fire protection work.

C. Perform repairs with materials that match existing in accordance with the appropriate sections of these specifications.

3.3 TRENCHING, EXCAVATION AND BACKFILLING

A. Provide trenching, excavation and backfilling necessary for performance of fire protection work in accordance with the appropriate section of these specifications.

3.4 IDENTIFICATION

A. Identify exposed or accessible piping with stenciling contents indicating pipe contents and direction of flow on piping not more than 20 feet apart, at valves, at access panels, and at least once above each space.

B. Contractor’s option to identify exposed or accessible piping with snap-on or strap-on type markers. Color code markers in accordance with ANSI. Indicate pipe contents and direction of flow on marker. Install markers on piping not more than 20 feet apart, at valves, at access panels, and at least once above each space.

C. Color code piping exposed in equipment rooms. Paint to be Sherwin Williams Metalatex fire protection red.
D. Identify all mechanical equipment with engraved brass, aluminum, or stainless steel nameplates or tags. Use equipment names and numbers appearing in schedules on drawings. Fasten nameplates to equipment using screws. Glue or adhesive is not acceptable. Fasten tags to equipment using brass, aluminum or stainless steel chains.

E. Identify each valve with engraved brass, aluminum, or stainless steel identification tag indicating valve service and sequential identification number. Attach tag to valve handle with brass, aluminum or stainless steel chain. Provide two bound manuals to Owner listing each valve sequentially and indicating valve manufacturer, style, size, service, normal position, and specific location for each valve.

F. Frame and mount control diagrams and sequences in each equipment room. Use non-fading black and white prints encased in aluminum frame with plexiglass cover.

3.5 CLEANING

A. Repair damaged factory finishes covering all bare places and scratches.

3.6 FOUNDATIONS AND PADS

A. Provide foundations, pads, and bases required for equipment. Concrete to be in accordance with concrete division of specifications.

B. Coordinate proper sizes and locations of foundations, pads, bases, anchors, supports, and other items to be built into structure.

3.7 TESTING

A. Test all installed equipment and systems and demonstrate proper operation. Correct and retest work found defective when tested.

B. Thoroughly check piping system for leaks. Do not add any leak-stop compounds to the system. Make repairs to piping system with new materials. Peening, doping, or caulking of joints or holes is not acceptable.

END OF SECTION 210100
PART 1 GENERAL

1.1 DESCRIPTION
B. All equipment manufacturers shall submit, as part of the equipment submittal, compliance certifications. Contractor to provide equipment anchorage details specific to each unit provided.
C. At seismic restraint installation locations, provide vertical support systems engineered to accommodate dead load plus seismic force reactions.

1.2 RELATED SPECIFICATION SECTIONS
A. Section 210100 - Fire Protection
B. Section 211313 - Automatic Sprinkler Systems

1.3 REFERENCES
A. Publications, codes and standards listed below form a part of this specification to the extent referenced.
1. 2012 International Building Code (IBC)
   a. Chapter 16 - Structural Design
   b. Chapter 17 – Structural Tests And Special Inspections
2. ASCE 7-05, Chapter 13, Minimum Design Loads For Buildings and Other Structures, American Society of Civil Engineers (ASCE).
3. ACI 318, Building Code Requirements for Structural Concrete, American Concrete Institute (ACI).

1.4 COMPONENT IMPORTANCE FACTOR
A. In order to identify systems requiring seismic restraint and to define those from which restraints may be excluded, utility components are assigned an ASCE 7 Importance Factor (Ip) on the basis of the following:
B. \( I_p = 1.5 \)
   1. Seismic Use Group II or III, essential facilities required for post-earthquake recovery – all “Designated Seismic Systems” per IBC Chapter 16 required for the continued operation of the facility.
   2. Life-safety component which is required to function after a seismic event including fire protection sprinkler systems.
   3. Components that contain hazardous or flammable materials.

1.5 SUBMITTALS

A. Equipment Certification.
   1. Equipment manufacturer to provide certificate of compliance for 2012 IBC proxing on line capability for the project use group and seismic design category. Provide certifications for the following equipment: Components with hazardous contents, built up or field assembled plumbing equipment, fire suppression control panels, pre action control panels, and auxiliary or remote power supplies, and above ground storage tanks. Equipment manufacturer certification to be based on shake table or three dimensional shock testing or experience data as required by ASCE/SEI 7-05.
   2. The following equipment is considered rugged and does not require a certificate of compliance: pumps, valves, motors, air compressors, and underground tanks.

B. Contractor to identify and convey each overhead deck condition to which seismic attachments will be made. Information to include type and density of concrete, concrete thickness, size and gage of metal deck and any point load limitations or restrictions.

C. Provide Seismic Design Force calculations per ASCE 7-05, Formulas 13.3-1 thru 13.3-3 stamped by a registered design professional qualified civil or structural engineer licensed to practice in the State where project is located. For multi-story projects, provide calculated Seismic Design Force for each floor.

D. Submit seismic restraint layouts stamped by a registered design professional qualified civil or structural engineer licensed to practice in the State where project is located. Seismic restraint layouts to show:
   1. All vertical support and seismic brace locations.
   2. All anchorage connections to structure. Anchor brand, type, quantity and size.
   3. Vertical support and brace reaction point load at all connections to structure. For review by engineer of record in checking suitability of the building structure to accommodate imposed loads.
   4. Plan set sheets showing appropriate installation details reflecting actual job site conditions.

E. Include cover sheet with Seismic Restraint Bracing Legend delineating:
   1. Maximum Allowable Size or Utility Weight (Lbs/Lf).
5. Transverse Brace Reaction.
7. Longitudinal Brace Reaction.
8. Minimum Required Seismic Restraint Brace Arm Assembly.
10. Installation Detail Drawing References.

1.6 QUALITY ASSURANCE

A. Registered design professional completing seismic submittal to check suitability of structure to accommodate applied seismic loads.

B. Registered design professional completing seismic submittal is to provide a “Statement of Special Inspections” in conformance with 2012 IBC, Chapter 17.

C. Each contractor responsible for the construction of a “Designated Seismic System” shall submit to the building official and owner prior to the commencement of work on the system or component a written “statement of responsibility” per IBC Chapter 17.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Seismic restraint hardware and engineering by International Seismic Application Technology (ISAT), Mason Industries, Tolco, or approved equal.

B. Vertical support and seismic restraint anchorages to utilize Cast-In Place Deck Inserts, or Post Installed Anchors. All deck inserts or post installed anchors to have a valid ICC ESR evaluation report (or equal) substantiating the insert or anchor capacity.

C. Vertical support and seismic restraint connections to structural steel are to utilize fixed Beam Clamp connections or Welded or bolted connections.

PART 3 EXECUTION

3.1 INSTALLATION

A. Roof mounted equipment: All roof mounted equipment is to be positively attached to roof support curb or isolators by bolting or welding. All support curbs to resist compressive, shear, tension, and rotational loads (including seismic loads) and translate these loads to building structure. The design of all support curbs shall be performed by an engineer licensed in the project state. Curb design to minimize rotational loads to structure and be positively attached to building structure by bolting or welding.
B. For conditions not covered within pre-engineered drawings, the required engineering is to be performed by a registered Engineer.

C. Manufacturer shall provide field installation training prior to commencement of install.

D. Field relocation of any seismic installation points away from that shown on the furnished shop drawing layouts shall be coordinated with registered design professional who completed seismic submittal.

E. Consult registered design professional who completed seismic submittal when field conditions prohibit compliance with the supplied installation details.

F. In order to satisfy ASCE 7 minimum yield strength requirements, the allowable brace spacing for non-ductile systems (eg. cast iron, plastic and glass pipe) shall be no more than half that for ductile systems.

3.2 EQUIPMENT CONNECTIONS

A. Where seismic bracing is allowed to be omitted due to size or proximity to overhead deck, all terminations to fixed equipment, panels, etc. or to other portions of the system requiring seismic restraint are to utilize flexible connectors.

B. Where seismic bracing is allowed by code to be omitted due to size or proximity to overhead deck, contractor shall be responsible for assuring that damaging impact or vertical support failure cannot occur.

3.3 SPECIAL INSPECTION

A. Special Inspection Requirements: All Designated Seismic Systems are subject to Special Inspection per IBC Chapter 17.

B. Special inspection for mechanical components shall be provided as follows:
   1. For all Designated Seismic Systems within seismic design categories D, E or F.
   2. Periodic special inspection during the installation of vibration isolation systems where the construction documents indicate a maximum clearance (air gap) between the equipment support frame and restraint less than or equal to 1/4 inch.

C. Install identification tags at all seismic brace locations. Tags to include the following information:
   1. Specific seismic forces (g-force) the location was designed to resist.
   2. Maximum brace reaction at connection to structure.
   3. For single hung items, the maximum pipe/conduit size the brace location was designed to accommodate.
   4. For trapeze supported items, the maximum weight (lbs/lf) the brace location was designed to accommodate.
5. For suspended equipment, the maximum unit operating weight (lbs) the brace location was designed to accommodate.

6. Location identifier cross matched to that on plan set layout.

7. Company name of installing contractor.

D. Upon completion of construction a Quality Assurance Representative of registered design professional who completed seismic submittal shall review the installation of the seismic-force-resisting system and provide documentation indicating general conformance to seismic restraint layout drawing.

END OF SECTION 210547
SECTION 211119
FIRE DEPARTMENT CONNECTION

PART 1 GENERAL

1.1 WORK INCLUDED
A. Furnish materials, accessories, equipment, tools, and transportation and performance of all services and labor required to completely execute the sprinkler and fire protection work for this project, as indicated on the drawings and as herein specified.

1.2 SCOPE OF WORK
A. Cutting of holes necessary for the installation of work specified under this Section. Coordinate cutting of material with other Divisions. Employ services of other trades for patching of concrete, masonry, and other material. Use same material for patching and finish neatly.

1.3 DESIGN REQUIREMENTS
A. Install in accordance with the drawings, specifications, and requirements of NFPA 13.
B. Furnish material and labor necessary to fully comply with the drawings and specifications and with the rules, regulations, and ordinances.
   1. Provide a 3/4 inch ball drip for all types of fire department connections. Route discharge, to outside of building.

1.4 QUALITY ASSURANCE
A. Materials bearing UL and FM approval, where such approval is applicable or required by the agencies having jurisdiction over fire protection work.
B. Provide all hose threads, operating nuts, and accessories for Siamese connections, meeting local Fire Department Standard.
C. The installing sprinkler contractor shall be licensed or permitted by the state and local authority having jurisdiction to perform fire protection installations. This shall be in compliance with all applicable state and local laws.

1.5 SUBMITTALS
A. Equipment submittal drawings and data are required on all items named by manufacturer, including the following:
   1. Siamese Connection - Type and Manufacturer.
1.6 APPLICABLE CODES
   A. NFPA 13

PART 2 PRODUCTS
2.1 ACCEPTABLE MANUFACTURERS
   A. Acceptable Manufacturers: Croker-Standard, Potter Roemer, Elkhart.
   B. Products listed indicate standard.

2.2 FIRE DEPARTMENT CONNECTIONS
   A. Provide signage per NFPA 13 and requirements of local authority having jurisdiction for proper identification for fire department service.
      1. Fire Department Connection (Siamese): Croker-Standard, Figure Number 6010-PB 4 inch by 2-1/2 inch two-way, flushed polished brass, with double clapper inlets siamese fire department connection. Hose threads shall be in accordance with local fire department requirements. Provide plugs with chains.

PART 3 EXECUTION
3.1 COORDINATION
   A. Coordinate installation with other Divisions to ensure there are no conflicts.

END OF SECTION 211119
PART 1 GENERAL

1.1 WORK INCLUDED

A. Furnish materials, accessories, equipment, tools, and transportation and performance of all services and labor required to completely execute the sprinkler and fire protection work for this project, as indicated on the drawings and as herein specified.

1.2 SCOPE OF WORK

A. Shop drawings.
B. Valves including check valves and system valves.
C. Pipe, fittings, exterior.
D. Pipe, fittings, interior.
E. Hangers, supports and sleeves.
F. Sprinkler heads, extra sprinkler cabinet.
G. Alarm check valves and accessories.
H. Testing and flushing.
I. Excavation and backfill.
J. Hydraulically calculate sprinkler system, wet and/or dry as required by drawings. Maximum water velocity shall be 25 feet per second.
K. Cutting of holes necessary for the installation of work specified under this Section. Coordinate cutting of material with other Divisions. Employ services of other trades for patching of concrete, masonry, and other material. Use same material for patching and finish neatly.
L. Unless otherwise noted on the drawings or these specifications, the entire project shall be fully protected, excluding no spaces.
1.3 DESIGN REQUIREMENTS

A. Install system(s) in accordance with the drawings, specifications, and requirements of NFPA 13 and NFPA 25.

B. Furnish material and labor necessary to fully comply with the drawings and specifications and with the rules, regulations, and ordinances.

C. Reduction of the system area of operation as allowed per NFPA 13 is not acceptable on this project.

D. Small room rule as allowed per NFPA 13 is not acceptable on this project.

E. Include in sprinkler system design the following requirements:
   1. Light Hazard Occupancies (offices, patient rooms, corridors, lobbies, classrooms, hotel guest rooms, institutional, residential, libraries with 8 ft. high shelves max, unused attics) shall be 0.10 GPM/sq. ft. over 1500 sq. ft.
   2. Ordinary Hazard Group 1 Occupancies (electrical rooms, mechanical rooms, storage rooms, kitchens, parking garages, laundries, restaurant service areas, and similar areas) shall be 0.15 GPM/sq. ft. over 1500 sq. ft.
   3. Ordinary Hazard Group 2 Occupancies (medical record, boiler rooms, loading docks, machine shop, mercantile, libraries with large stack areas, trash rooms and similar areas) shall be 0.20 GPM/sq. ft. over 1500 sq. ft.
   4. Extra Hazard Group 1 Occupancies (emergency generator room and similar areas) shall be 0.30 GPM/sq. ft. over 2500 sq. ft.
   5. Canopies and overhangs utilizing Dry Pipe sprinkler systems shall be designed on an Ordinary Hazard Group 1 basis, utilizing 30 percent additional square footage for coverage (i.e., 0.15 GPM/sq. ft. over 1950 sq. ft.).
   6. Provide 286 degree F. sprinkler heads in mechanical rooms, boiler rooms, elevator shafts and machine rooms, and other related high ambient temperature spaces.
   7. Provide hose streams as required by NFPA 13.
   8. Provide a minimum of 18 inches clearance between bottom of sprinkler deflector and top of storage.
   9. Provide a pre-action sprinkler system serving data processing areas, elevator machine/equipment rooms. Provide OS&Y, valve with tamper switch, electric release deluge valve, control cabinet, drain line and valve down stream of OS&Y valve. Interconnect the control cabinet with the fire alarm system to allow sprinkler water to flow following the sequence of elevator operation and shutdown specified under Division 26.
   11. Provide a 3/4 inch ball drip for all types of fire department connections. Route discharge to outside of building.
   12. Provide the results of a Contractor independently performed flow test in accordance to NFPA 291 within 6 months to determine the adequacy of the water supply before construction begins. The Contractor shall use this data
obtained to hydraulically design the system. Submit this with sprinkler system drawings and calculations.

13. The hydraulic calculations shall be carried to the city water supply taking into account all fittings, valves, etc. The contractor shall be responsible for hydraulically sizing all new piping not sized on the drawings and shall take into consideration the existing piping to remain.
   a. Design calculations shall have a minimum of 5% difference of system demand including hose stream and the available water supply flow and pressure.

1.4 QUALITY ASSURANCE

A. Materials bearing UL and FM approval, where such approval is applicable or required by the agencies having jurisdiction over fire protection work.

B. The installing sprinkler contractor shall be licensed or permitted by the state and local authority having jurisdiction to perform fire protection installations. This shall be in compliance with all applicable state and local laws.

C. All sprinkler piping from “Point of Service” including underground used for sprinkler or standpipe system shall be installed by a Registered Sprinkler Contractor. Underground mains and hydrants must be installed and in service prior to starting construction.

D. All castings used for coupling housings, fittings and valve bodies shall be date stamped for quality assurance and traceability.

1.5 SUBMITTALS AND SHOP DRAWINGS

A. The Contract Documents contain fire protection design drawings which indicate minor coordination. It is the responsibility of the Contractor to prepare detailed and coordinated working drawings and calculations, accurately representing the design of record.

B. Prepare complete detailed working drawings for Fire Protection System. Submit drawings to Designer and to owner's insurance underwriter for approval. After receiving this approval, submit shop drawings to State Fire Marshal and local AHJ for his review and approval prior to starting installation. Prior approval by above listed authorities is required before sprinkler installation is begun.

C. The Sprinkler Contractor shop drawings and calculations shall be stamped and signed by a firm employee who has a minimum NICET III level certification and signed by a Responsible Managing Employee. Shop drawings and calculations shall be submitted by a licensed and registered fire protection contractor.

D. Equipment submittal drawings and data are required on all items named by manufacturer, including the following:
   1. Sprinkler Heads - Type and Manufacturer. The mixing of sprinkler manufacturer shall not be permitted.
2. Valves - Type and Manufacturer, interior and exterior. Sprinkler devices (alarm check valves, dry pipe valves, etc.) shall be listed and approved as component packages and no intermixing of valve manufacturers shall be allowed.

3. Water Flow, Pressure and Tamper Switches - Type and Manufacturer.

4. Piping and fittings.

E. The sprinkler system shall be hydraulically designed by industry standard computer software. The Contractor shall submit computer calculations and copy of original water flow test report with working plans. Include in calculations allowance for outside hose streams and domestic water as required.

F. Where seismic bracing is required by code, the Contractor will submit with the working plans copies of seismic bracing work sheets (ref. 2013 NFPA 13 - Fig. A.9.3.5(a)) or copies of computer generated seismic bracing calculations. Refer to specification section 210547 for additional requirements.

G. Contractor will supply as-built drawings to the Owner, the Owner's Insurer, the Architect, the Engineer and other entities as required by the Owner or the Authority Having Jurisdiction.

1.6 SPRINKLER SYSTEM COORDINATION

A. The contractor will be responsible for ensuring that the reflected ceiling plan shown on the working drawings is the latest revision from the Architect before commencing work.

B. The contractor shall be responsible for providing to the Architect notification for any drawing changes resulting from movement of sprinkler piping or heads during installation.

C. Failure to coordinate sprinkler system and building systems (including, but not limited to: ductwork, mechanical piping, and lighting fixtures) prior to fabrication or installation of sprinkler systems shall be corrected, modified, or changed as necessary at the expense of the contractor.

D. The contractor is to completely investigate, PRIOR TO BID, all requirements of local water utility and fire department. Devices such as ADT and/or local alarm systems, double check valve assemblies, detector checks, tamper switches shall be provided complete, wired, connected, and installed in accordance with local authorities by this Contractor. In the event the authorities have no installation details, the Contractor shall submit for approval proposed installation.

1.7 APPLICABLE CODES

A. NFPA 13

B. NFPA 25
PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Products listed indicate standard.

2.2 VALVES

A. Acceptable Valve Manufacturers: Ames, Nibco, Anvil, Kennedy, Wilkins, Tyco or Victaulic.

B. Interior Valves
   1. Check valves
      a. Iron body, Kennedy Valve 1126A swing check valve with resilient disc, flanged body.
      b. Bronze body, Nibco KT-403-W threaded swing check valve with dielectric unions.
      c. Ductile iron body, Tyco CV-1F swing check valve with grooved ends.
   2. Gate valves
      b. Bronze body, OS&Y gate valve, Nibco T-104-0, threaded with dielectric unions.
      c. Ductile iron body, OS&Y gate valve, Tyco with grooved ends.
   3. Butterfly valves
      a. Butterfly valves shall be approved in writing with Engineer prior to bid.
      b. Butterfly valves are not acceptable on this project.
      c. Ductile iron body, indicating type, Kennedy Valve W300 with integral supervisory tamper switch, flanged.
      d. Ductile iron body, indicating type, Tyco BFV-N with grooved ends.
      e. Butterfly valves are not allowed on suction side of fire pumps.

2.3 PIPE AND FITTINGS

A. Interior Pipe and Fittings
   1. Piping for wet pipe systems shall be Schedule 40 black steel pipe 2” and smaller conforming to ASTM A135 or ASTM A53 and Schedule 10 black steel pipe 2-1/2” and larger conforming to ASTM A135.
   2. Fittings for wet pipe systems
      a. Fittings shall be threaded or grooved for 2 inch and smaller and flanged or grooved for pipe 2-1/2 inch and larger.
      b. Ductile iron threaded fittings, ANSI B16.3 Class 300.
      c. Cast iron threaded fittings, ANSI B16.4 Class 125 and 300 (extra heavy).
      d. Cast iron flanged fittings, ANSI B16.1 Class 125 and 300.
      e. Grooved couplings and fittings, as manufactured by Tyco, Anvil, Victaulic or equivalent. Couplings shall be rigid type, equivalent to Tyco 577 Rigid Coupling with pre-lubricated Grade “A” EPDM gasket. All groove couplings and fittings shall be furnished by a single manufacturer. Associated piping shall be roll-grooved.
f. Weldolet pipe outlets for branch connections shall be of approved manufacturer.

3. Piping for Dry Pipe systems and for drainage systems shall be Schedule 40 galvanized steel pipe, conforming to ASTM A795 with galvanized fittings, ANSI B16.4, galvanized coated, both interior and exterior of pipe and fittings.

4. Fittings for dry pipe systems
   a. Fittings shall be threaded or grooved for pipe 2 inch and smaller and flanged or grooved for pipe 2-1/2 inch and larger. Contractor has option of providing threaded piping for 6 inch and larger.
   b. Ductile iron threaded fittings, ANSI B16.3 Class 300 hot-dipped galvanized conforming to ASTM A153.
   c. Cast iron threaded fittings, ANSI B16.4 Class 125 and 300 (extra heavy) hot-dipped galvanized conforming to ASTM A153.
   d. Cast iron flanged fittings, ANSI B16.1 Class 125 and 300 hot-dipped galvanized conforming to ASTM A153.
   e. Grooved couplings and fittings, as manufactured by Tyco, Anvil, Victaulic or equivalent. Couplings shall be rigid type, equivalent to Tyco 577 Rigid Coupling with Tri-Seal Grade "E" EPDM gasket. All groove couplings and fittings shall be hot-dipped galvanized conforming to ASTM A153 and furnished by a single manufacturer. Associated piping shall be roll-grooved.
   f. Weldolet pipe outlets for branch connections shall be of approved manufacturer.

5. Flexible sprinkler drops shall be UL Listed and FM approved. The maximum length shall not exceed 4'-0" and the minimum bend radius shall not exceed the more stringent of the UL and FM guidelines. Flexible drops shall be installed per manufacturers printed instructions with mounting brackets supplied by the same manufacturer. Hydraulic calculations shall allow for length of flexible drop used. Submit all product data including manufacturers mounting instructions with shop drawings submitted.

6. Mechanical tees are not allowed on this project.

B. Hangers, Supports, and Sleeves
   2. Adjustable Clevis: Anvil Fig. 260.
   3. Adjustable Swivel: Anvil Fig. 69. Beam Clamp with Anvil Fig. 92 or Anvil Fig. 218 with retaining strap. If Fig. 218 is used provided Fig. 157 rod attachment. Retaining strap shall be UL listed and FM approved for seismic applications. Retaining strap shall be approved by the Engineer in writing prior to bid.
   4. Concrete Fasteners: Anvil steel shell and expander plug.
   5. Concrete Insert: Anvil Fig. 152.
   6. Riser Clamp: Anvil Fig. 261.
   7. Powder-driven inserts shall not be accepted.
   8. All pipes passing through rated floors or walls shall be sleeved and/or firestopped to an equivalent rating of the floor or wall assembly. Firestop materials shall meet ASTM E814 requirements.
   9. All piping hangers and seismic braces shall be listed for use with sprinkler systems or shall be designed by a registered Structural Engineer, licensed to practice in the State. Refer to specifications 21 05 47 for additional requirements.
10. All hangers, bracing, etc., shall be designed to constrain the sprinkler discharge resulting from a system pressure of 175 psig at the base of the riser.

2.4 SPRINKLER HEADS, EXTRA SPRINKLER CABINET

A. Provide the following sprinkler heads of proper types, ratings, and spacings for areas involved. Provide appropriate finishes compatible with space finishes being served. Acceptable manufacturers: Tyco, Viking, Victaulic and Reliable.

1. Quick Response Type
   a. Pendent and upright or chrome: Tyco TY-FRB (UL and F.M. approved). K-Factor = 5.6
   b. Recessed, chrome: Tyco TY-FRB (UL and F.M. approved). K-Factor = 5.6
   c. Fully concealed: Tyco-RF II, white coverplate. (UL approved). K-Factor = 5.6
   d. Horizontal sidewall: Tyco-FRB (UL and FM approved) chrome.
   e. Dry: Tyco Model DS-1 (UL approved) standard coverage sidewall. K-Factor = 5.6.
   f. Institutional: Tyco “Raven” (UL approved) or chrome and Tyco “Raven” (UL approved). K-Factor = 5.6.

2. Extended Coverage Quick Response Heads
   a. Pendent and Upright or chrome: Tyco EC-11; (UL and FM approved) K-Factor = 11.2.
   c. Sidewall: Tyco FRB or chrome.
   d. Fully Concealed: Tyco-RF 11, white coverplate. (UL approved) K-Factor=5.6
   e. Dry: Tyco DS-2 extended coverage or Tyco DS-1 sidewall (UL approved) K-Factor = 5.6.

B. Pendent heads in ceilings and horizontal sidewall heads shall have one-piece, non-adjustable escutcheons. Two-piece or slip type escutcheons shall not be accepted. This does not apply to recessed heads. Escutcheon shall be approved for use and supplied by the sprinkler manufacturer.

C. Sprinkler body shall be integrally cast with a hex-shaped wrench boss to reduce the risk of damage during installation. Wrenches shall be provided by the sprinkler manufacturer which directly engages the wrench boss.

D. Provide sprinkler cabinet equal to Tyco with spare sprinkler wrench.

E. Contractor shall coordinate dry barrel length as required for field conditions.

2.5 SWITCHES

A. Water Flow Switch: System Sensor Model WFD or Notifier Model No. WFD-60 24 VDC vane type flow switch with pneumatic retard adjustable from 0 to 70 seconds, complete with two sets of single pole, double throw micro feature. Coordinate final voltage with Division 26.
B. Tamper Switches: System Sensor PIBV2(A) or Notifier Model No. PIBV2(A) for 4" and larger, Potter Model No. OSYSU-2 24 VDC for pipe size less than 4", tamper switch double pole, double throw micro feature for ½-inch to 12-inch valves. Coordinate final voltage with Division 26.

2.6 WATER FLOWALARMS


B. Contractors Option: Contractor has option of providing electric bell in lieu of water gong. If contractor chooses this option, all required coordination with Division 26 and changes shall be provided at no additional cost to Owner.

2.7 WET ALARM CHECK VALVES AND ACCESSORIES

A. Wet Alarm Check Valve and Accessories – Electric Bell
   1. Alarm check valve shall be equal to Tyco CV-1FR with resilient elastomer seal facing on the spring-loaded clapper.
   2. Provide trim package to control include as a minimum as follows:
      a. Main drain valve.
      b. Pressure gauges (system and supply).
      c. All installed components shall be replaceable without removing the valve from the installed position.
   3. Provide waterflow switch connected to electric bell and fire alarm system.

B. “Shot-gun” riser assembly are not allowed on the project.

2.8 INSPECTOR TEST AND DRAIN

A. Where indicated on drawings (riser or remote location), Inspector test and drain shall have:
   2. Components: A tamper resistant test orifice and a tapped port for system access.
   3. Pressure Relief Valve and Drainage Piping: AGF Model 7000.
      a. Pressure Rating: Factory rated at 175 psi.
      b. Body Material: Bronze body and stainless steel spring.
      c. Components: Nylobraid flexible tube, two 1/2" NPT by barbed 90 degree elbows, external identification plate and integral flushing handle to remove debris.
      d. 1/2 inch MIPT inlet, 1/2 inch FIPT outlet.
      e. Relief pressure shall be factory set to project specifications.
      f. Relief valve shall operate to the OPEN position between 90% and 105% of the set pressure.
      g. Relief valve shall reseat or CLOSE at a minimum of 80% of set pressure.
   4. Test Orifice Size: Normal 1/2" (5.6), as required by NFPA 13, latest edition.
5. Size: F.I.P.T., same as connected piping.
6. Inlet and Outlet: Threaded.

PART 3 EXECUTION

3.1 COORDINATION

A. Coordinate installation with other Divisions to ensure there are no conflicts. Fire protection piping shall not take priority in routing over HVAC ductwork.

3.2 PIPE INSTALLATION

A. Connect to water main as shown on drawings.

B. Attach hangers to structural steel work as specified above, except that structural work shall not be drilled and punched. Wherever necessary, furnish, install, and securely anchor to or between building members suitable angle iron or other steel members to support sprinkler work.

C. Provide support for grooved piping in conformance with requirements of MSS-SP-69, "Pipe Hangers and Supports - Selection and Application". In addition to these requirements, leave no horizontal pipe unsupported between any two couplings nor shall any pipe be left unsupported whenever a change in direction of flow takes place. Provide supports meeting the requirements stated above, but ensure that the distance between supports does not exceed the following:

<table>
<thead>
<tr>
<th>PIPE SIZE</th>
<th>MAXIMUM SPAN BETWEEN HANGERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Inch</td>
<td>8 Feet</td>
</tr>
<tr>
<td>1-1/4 through 2 Inch</td>
<td>10 Feet</td>
</tr>
<tr>
<td>2-1/2 through 4 Inch</td>
<td>12 Feet</td>
</tr>
<tr>
<td>5 through 8 Inch</td>
<td>14 Feet</td>
</tr>
<tr>
<td>10 through 12 Inch</td>
<td>15 Feet</td>
</tr>
</tbody>
</table>

D. Support vertical piping at every other floor or every other pipe length, whichever is most frequent. Set the base of the riser or base fitting on a pedestal or foundation.

E. Seismic Application: The use of single sided or friction type C-clamps with retention straps for hanging pipe shall be UL and FM approved for seismic application.

F. Where seismic bracing is indicated on plans, the Contractor will submit with the working plans copies of seismic bracing work sheets (ref. NFPA 13 - Fig. A.9.3.5(a)) or copies of seismic bracing calculations from industry standard computer software in accordance with seismic design category and ASCE07. Refer to specification section 210547 for additional information.

G. Piping Above Grade:
1. In areas with no ceilings, run piping as high as possible. Minimum head room shall be 10'-0".
2. Contractor is responsible for installation of seismic bracing required by code. The Contractor is responsible for coordinating with the Structural Engineer regarding proper seismic bracing. Refer to Section 210547 for additional information.

3. Grooved joint shall be installed in accordance with the manufacture’s written recommendations. Grooved ends shall be clean and free from indentations, projections or roll marks. The gasket shall be molded and produced by the coupling manufacturer of an elastomer suitable for the intended service. The coupling manufacturer’s factory trained representative shall provide on-site training for the Contractor’s field personnel in the use of grooving tools and installation of product. The representative shall periodically visit the job site to ensure the best practices in grooved product installation are being followed. (A distributor’s representative is not considered qualified to conduct the training.

H. Provide section valves where shown on drawings, complete with tamper switch, water flow alarm, and drain connections. Provide sight-glass where inspector’s test discharge cannot be readily seen when operating valve.

I. All control valves and indicating valves shall be chained into the open position and equipped with remote or central station signaling devices per 2013 NFPA 13 – 8.16.1.1.2.1.

J. All sprinkler piping shall be hydrostatically tested at 200 psi and shall maintain that pressure with no loss for 2 hours or as required by NFPA 13 for normal pressure in excess of 150 psi.

K. Provide drain valves, pipes and test connections as required by NFPA 13. Pipe drain lines and test connections to outside building as shown on the drawings and details. Test lines must originate from the most hydraulically remote point of each sprinkler zone. All drain piping and fittings shall be galvanized coated, no exception.

L. Cross mains and feed mains shall not pass through electrical rooms or similar spaces. Only the branch line serving such spaces shall be permitted within the boundaries of these rooms.

M. Drain plugs shall be installed on trapped sections of piping between 5 and 50 gallons. Auxiliary drain valves, 1 inch or larger, shall be installed on trapped sections of pipe greater than 50 gallons, and piped to an accessible location.

3.3 SPRINKLERS

A. Install sprinkler heads and required piping in areas such as concealed spaces, and spaces as required by NFPA 13, NFPA 101, applicable state and local codes.

B. Install sprinkler heads centerline of corridors and locate in the center of the ceiling tiles. Install sprinkler heads in other designated spaces in the center of the ceiling tiles and symmetrically locate with other heads within the ceiling. (Refer to Architectural reflected ceiling plans.) Do not install sprinkler heads in other locations any closer than six (6) inches to any ceiling grid or wall.
C. Pendant sprinklers below ceiling shall be in alignment and parallel to ceiling features, walls, etc.

D. When the light fixtures extend below the ceiling, the sprinklers shall be spaced so that the sprinkler spray pattern is not obstructed. Refer to electrical plans for light fixture layout and types.

E. Provide guards on sprinkler heads where within 7'-6" of finished floor or wherever sprinklers may be subject to mechanical injury.

F. Do not install sprinklers which have been dropped, damaged or show a visible loss of fluid. Never install sprinklers with cracked bulb.

G. Furnish one sprinkler cabinet complete with 12 sprinklers of assorted temperature ratings of the type necessary and in use throughout the installation, including one sprinkler wrench. Locate and mount adjacent to riser.

3.4 MATERIAL AND TEST CERTIFICATE

A. Provide copy of Contractor’s Material and Test Certificate for underground and above ground piping as required by NFPA 13 and NFPA 24 in Owners O&M Manual.

3.5 OWNER’S INFORMATION CERTIFICATE

A. Before commencing work, the sprinkler contractor shall obtain from the Owner, or his Agent, an Owner’s Information Certification containing the elements outlined in 2013 NFPA 13 – 4.3.

B. The Contractor shall provide a copy of the Owner’s Certificate to the Engineer.

3.6 GUARANTEE

A. The fire protection installation, as specified under this section of the specifications, shall be guaranteed for one year against defective equipment, materials, and workmanship.

B. Guarantee shall not be construed as requiring the sprinkler contractor to render service or maintenance required in the normal operation of the equipment or to make repairs that may be needed due to normal wear and tear or the Owner’s negligence, abuse, or breakage.

3.7 INSPECTION SERVICE

A. After completion of the fire protection installation and at the start of the guarantee year, the Contractor shall execute the National Fire Sprinkler Association., Standard form of “Inspection Agreement,” without charge to the Owner, calling for four inspections of the sprinkler system during the guarantee year. These inspections will, at a minimum, comply with the provisions and requirements of NFPA 25. During the guarantee year,
the inspections shall be made as per the inspection agreement, plus the following maintenance to be performed during the course of the fourth inspection.

B. Operation of all control valves.

C. Lubrication of operating stems of all interior control valves.

D. Operation of water motor gong and/or electric alarms.

E. Cleaning of alarm valves.

F. Cleaning of dry pipe valves.

G. Lubrication of Fire Department Connection inlets.

H. The Standard Form of the National Fire Sprinkler Association, “Report of Inspection” shall be filled out in triplicate after each inspection and the copies sent to the Owner, Insurance Carriers, Fire Department, or other authorities that the Owner may designate.

END OF SECTION 211313
PART 1 GENERAL

1.1 WORK INCLUDED

A. Provide all labor, materials, tools, and services for a complete installation of equipment and systems contained in contract documents.

B. Principal features of work included are plumbing system.

1.2 RELATED WORK

A. Electrical power and interlock and control wiring and conduit.

B. Field painting of equipment, and piping.

1.3 GENERAL

A. The contract documents form a guide for a complete system. Provide all items necessary to provide a complete system but not specifically mentioned, such as hangers, transitions, offsets, and drains.

B. Layouts indicated on drawings are diagrammatical only. Coordinate exact location of equipment, ductwork, and piping to eliminate conflict with other divisions. Designer reserves right to make reasonable changes in location of equipment, ductwork, and piping prior to construction.

C. Should Contractor find during progress of work that in his judgment existing conditions make desirable a modification, report such item promptly to Designer for instructions. Do not make deviations from contract documents without review of Designer.

D. Supervise all work with a competent mechanic specifically qualified in mechanical discipline.

E. All products used for dispensing potable drinking water must be lead free and meet the requirements of NSF 61 and NSF 372 test standards via third party testing and certification.

F. Modifications to system or equipment shall be coordinated by General Contractor. Any associated increase of cost of utility service/feeds proposed by General Contractor or Subcontractor shall be the responsibility of the Contractor.
1.4 PERMITS
   A. Secure and pay for permits, licenses, and inspections for work under this Division, including water and sewage connections.

1.5 CODES
   A. Comply with all pertinent local, State, and national codes.

1.6 STANDARDS
   A. Comply with all pertinent standards. This list is provided as a convenience to Contractor and is not to be considered all inclusive.
      1. American Gas Association (AGA).
      2. CISPI Standard 301.
      3. ASTM A 74.

1.7 SUBMITTALS
   A. Submit for review complete brochures and shop drawings for materials and equipment proposed.
      1. Brochures: Submit complete descriptions, illustrations and specification data for materials and equipment proposed. Clearly indicate proposed items when other items are shown on same sheet. Submit samples on request and/or set up for inspection. Samples will be returned to Contractor.
      2. Submittals shall be submitted in line by line format. Each submittal shall be provided with a cover letter and supporting documentation indicating how the submittal meets each line of the referenced specification section. All discrepancies between the construction documents and the submitted product shall be clearly identified for engineer evaluation.
      3. If a product other than the basis of design is rejected by the engineer for any reason, the Contractor shall provide the basis of design product at no additional cost to the Owner.
      4. Shop Drawings:
         a. Complete equipment and piping systems in equipment rooms.
         b. Complete equipment and piping systems in entire building.
         c. Owner furnished equipment rough-in layouts.
         d. Firestop systems.

1.8 PROJECT MAINTENANCE MANUALS
   A. Prior to final acceptance of project, provide Owner with bound maintenance manuals.

1.9 PROJECT TECHNICAL INSTRUCTION
   A. Prior to final inspection of project, provide technical instruction to Owner as follows:
      1. Field Instruction: Provide explanation of how systems and equipment are to operate during each season and during emergencies.
2. Field Demonstration: Demonstrate operation and routine maintenance for systems and equipment.
3. Videotape: Provide videotape or DVD of field instruction and demonstration to Owner at completion.

1.10 CONSTRUCTION RECORD DOCUMENTS

A. Provide construction record documents. Keep at the project one set of drawings and daily record changes at the time they are made. Give drawings to Owner at project completion.

1.11 EXISTING SERVICES

A. Maintain existing services in operation during construction. Coordinate and schedule all service interruptions with Owner.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Provide materials and equipment of domestic manufacturer bearing the U.L. label when such label is available.

B. Cast Iron Soil Pipe and Fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute ® and listed by NSF® International.

PART 3 EXECUTION

3.1 COORDINATION

A. Coordinate locations of equipment and piping to eliminate conflict with other divisions.

B. Carefully examine contract documents to be thoroughly familiar with items which require plumbing or mechanical connections and coordination.

C. Provide proper chases and openings. Place sleeves and supports prior to pouring concrete or installation of masonry.

3.2 CUTTING AND PATCHING

A. Repair or replace routine damage caused by cutting in performance of contract.

B. Correct unnecessary damage caused due to installation of plumbing work.

C. Perform repairs with materials that match existing in accordance with the appropriate section of these specifications.
3.3 FLAShING, COUNTERFLAShING, AND SEALING
A. Flash, counterflash, and seal piping at penetrations of roofs and outside walls.

3.4 TRENCHING, EXCAVATION AND BACKFILLING
A. Excavate to a depth at least 6" below bottom of pipe and a minimum of 36" above top of pipe. Fill below pipe, around pipe, and minimum of 12" above pipe with sand or Class "B" crushed stone tamped firm and even. Provide topsoil for final layer of dirt (12" minimum). Provide 6" spacing between pipes and between pipe and trench sides. Hand-grade with batterboards placed every 25'. Backfill by hand. Do not use rock or stone above sand or Class "B" crushed stone.

3.5 CONNECTION TO EQUIPMENT
A. Rough-in and connect to sterilizers, lab equipment, kitchen equipment, and Owner furnished equipment and provide a shutoff valve and union at each connection. Operating valves and/or controls for this equipment will be provided as an integral part of the equipment. Do not rough-in until shop drawings showing rough-in locations have been reviewed by Designer.

3.6 FOUNDATIONS AND PADS
A. Provide foundations, pads, and bases required for equipment. Concrete to be in accordance with concrete division of specifications.
B. Coordinate proper sizes and locations of foundations, pads, bases, anchors, supports, and other items to be built into structure.

3.7 IDENTIFICATION
A. Identify exposed or accessible piping with stenciling contents indicating pipe contents and direction of flow on piping not more than 20 feet apart, at valves, at access panels, and at least once above each space.
B. Contractor’s option to identify exposed or accessible piping with snap-on or strap-on type markers. Color code markers in accordance with ANSI. Indicate pipe contents and direction of flow on marker. Install markers on piping not more than 20 feet apart, at valves, at access panels, and at least once above each space.
C. Sanitary waste, storm and buried lines need not be marked.
D. Identify all equipment with engraved brass, aluminum, or stainless steel nameplates or tags. Use equipment names and numbers appearing in schedules on drawings. Fasten nameplates to equipment using screws. Glue or adhesive is not acceptable. Fasten tags to equipment using brass, aluminum or stainless steel chains.
E. Identify each valve with engraved brass, aluminum, or stainless steel identification tag indicating valve service and sequential identification number. Attach tag to valve
handle with brass, aluminum or stainless steel chain. Provide two bound manuals to Owner listing each valve sequentially and indicating valve manufacturer, style, size, service, normal position, and specific location for each valve.

3.8 CLEANING

A. Repair damaged factory finishes covering all bare places and scratches.

B. Cleaning Domestic Water System: Flush domestic water system progressively by opening building outlets and permitting flow to continue from each until water runs clear. Sterilize system in accordance with requirements of State Department of Public Health by the following method or other method acceptable to local authorities:
   1. Introduce chlorine or a solution of calcium or sodium hypochlorite, filling lines slowly and applying sterilizing agent at a rate of 50 ppm of chlorine as determined by residual chlorine tests at ends of lines. Open and close all valves while the system is being chlorinated.
   2. After sterilizing agent has been applied and left standing for 24 hours, test for residual chlorine at ends of lines. If less than 25 ppm is indicated, repeat sterilizing process.
   3. After standing for 24 hours and tests show at least 25 ppm of residual chlorine, flush out system until all traces of chemical used are removed.

3.9 TESTING

A. Test all installed equipment and systems and demonstrate proper operation. Correct and retest work found defective when tested.

B. Thoroughly check piping system for leaks. Do not add any leak-stop compounds to the system. Make repairs to piping system with new materials. Peening, doping, or caulking of joints or holes is not acceptable.

C. Test hot and cold domestic water piping systems upon completion of rough-in and before connection to fixtures at a water pressure of 125 psig for two hours without leaks.

D. Test drainage and venting system with necessary openings plugged to permit system to be filled with water and subjected to a minimum water pressure of 10 feet head at top of system. System to hold water for two hours without a water level drop greater than 4" in a 4" standpipe and without visible leakage. Test system in sections if minimum head can be maintained in each section.

E. Conduct air or smoke test if in opinion of Designer reasonable cause exists to suspect leakage or low quality workmanship.

F. Test foundation drain system in sections of 100 foot lengths before and after backfilling. Pass plumbers tape or Roto-Rooter through drain sections to ensure there are no restrictions to water flow.
G. Test gas piping and compressed air piping with Nitrogen at 100 psi for two hours without leaks.

H. Test flush valves for proper operation.

END OF SECTION 220100
PART 1 GENERAL

1.1 WORK INCLUDED

A. Contractor shall provide all necessary labor, materials, tools, and equipment to perform work required on the drawings and specified herein.

B. Certain equipment and/or systems to be factory insulated by manufacturer. Factory insulation materials to be as specified in applicable sections of the specifications.

C. All pipe fittings, valves and strainers in insulated pipe systems to be insulated.

D. Thermal resistance "R" values used herein are expressed in units of "Hour, Degrees F., Sq. Ft./BTU per Inch of Thickness" on a flat surface at a mean temperature of 75 degrees F.

E. Note that where electric cable wrap is called for, insulation is to be applied over cable.

F. "Contractor's Option" referred to in Materials below indicates optional materials which may be used as equals.

1.2 DEFINITIONS

A. "Exposed" equipment, and piping are areas which will be visible without removing ceilings or opening access panels.

B. Outdoors is considered exposed to the weather.

C. Underground is buried, whereas in a trench below grade is considered concealed.

1.3 CERTIFICATION/QUALITY ASSURANCE

A. Products shall meet applicable national, state, and local building codes and be U.L. (or other recognized testing lab) listed for intended service.

B. All insulations, jackets, adhesives, coatings, sealers, and tapes shall have a flame spread rating of 25 or less and smoke development rating of 50 or less when tested in accordance with ASTM E-84, NFPA 225, U.L. 723, and further must meet the requirements of NFPA 90-A and applicable building and plumbing codes.

C. All insulation materials shall be delivered and stored in manufacturers' containers and kept free from dirt, water, chemical, and mechanical damage.
D. Insulation shall be applied in a workmanlike manner by experienced, qualified tradesmen.

E. Insulation shall not be applied until all pressure testing has been completed, inspected, and released for insulation application.

F. Surfaces shall be clean and dry.

G. Insulation joints shall be butted firmly together and all jackets and tapes shall be smoothly and securely installed.

H. Insulation for duct, pipe, and equipment for above grade exposed to weather outside building shall be certified as being self-extinguishing for 1" thickness in less than 53 seconds when tested in accordance with ASTM D-1692.

1.4 APPLICABLE CODES AND STANDARDS

A. ASTM E-84.

B. U.L. 723.

PART 2 PRODUCTS

2.1 MATERIALS FOR PIPE AND EQUIPMENT

A. Materials for Pipe and Equipment: Provide factory pre-molded or shop or site mitered segment type insulation for pipe, pipe fittings, and valves. Fitting insulation to be of same thickness and material as adjoining pipe insulation. All insulation and related materials such as tape and mastic to meet applicable building code requirements for fire and smoke development.

1. Fiberglass: Provide factory-formed, factory-jacketed fiberglass piping insulation. Product to be Manville "Micro-Lok 650" with "Type AP-T" jacketing or equivalent product manufactured by CertainTeed, Knauf, or Owens-Corning. Product to have continuous operational temperature limit of 850 degrees F and a minimum "R" value of 3.6 per inch (K=0.28) at 100 degrees F mean temperature. Jacket to be fiberglass reinforced kraft paper with aluminum foil and pressure sensitive closure system. Vapor-barrier mastic for application to below ambient pipe insulation shall be fungus resistant per ASTM D 5590 with 0 growth rating; Water based; Permeance per ASTM E 96, Procedure B, 0.013 perm or less at 43-mil dry film thickness suitable for indoor and jacketed outdoor use. Products: Foster 30-80 AF. Color: White. A breather mastic for application to above ambient pipe insulation (fittings, tees, valves, etc.) shall be water based Foster 46-50 mastic or Childers CP-10 / CP-11. Use fiberglass piping insulation for the following services:

a. Domestic hot water supply without recirculating system: 1-1/4" and under - 1" thick; 1-1/2" and greater – 1-1/2" thick.

b. Domestic hot water supply and recirculating return piping: 1-1/4 and under – 1" thick, 1-1/2" and greater 1-1/2 thick.
c. Domestic cold water piping: 1/2” thick.
d. Horizontal rainwater leaders, overflow leaders, and roof drain bodies: 1” thick.

2.2 MATERIALS FOR FITTINGS, VALVES, AND SPECIAL COVERINGS

A. Provide coverings and finishes for specific items hereinafter specified.
   1. Use pre-molded insulation fabricated by the manufacturer of insulation material or shop or site mitered segment type insulation for all pipe fittings, elbows, tees, valves, and couplings.
   2. PVC fitting covers over blanket fiberglass are NOT acceptable.
   3. Contractor’s option to provide factory pre-molded one-piece PVC insulated fitting covers, precut fiberglass insulation inserts, and necessary installation materials for all pipe fittings. Materials to be equal to Manville Zeston white, U.V. resistant, 25/50 rated, 20 mil thickness insulated PVC fitting covers and insulation inserts.

B. For any service, when below grade direct buried, cover straight pipe and fitting insulation with equivalent of Pittsburgh Corning "Pittwrap", Foster C.I. Wrap 50 mil or "Pittwrap SS11" jacketing. Valves in systems operating above 60 degrees F. and installed in valve boxes shall not be insulated; however, the valves shall be painted with a rust resistant product equivalent to Rustoleum.

C. When specifically approved by designer, when it is impossible to completely insulate pipe, fittings, or valves with specified insulation, Armstrong Armaflex insulation tape may be used to prevent condensate drip on small piping. Use of cork insulation tape is prohibited.

PART 3 EXECUTION

3.1 GENERAL

A. No insulation shall be cut where a hanger is located. If hangers have been installed by pipefitter tradesmen which violates this strict requirement, notify Designer immediately.

B. Piping systems shall be tested and found free of all leaks prior to installation of insulation covering.

C. All surfaces shall be clean and dry when covering is applied. Covering to be dry when installed and during application of any finish, unless such finish specifically requires a wetted surface for application.

D. All adhesives, cements, and mastics shall be compatible with materials applied and shall not attack materials in either wet or dry state.

E. Install insulation using professional insulators who have adequate experience and ability.

F. Exposed-to-view insulation shall have a well tailored appearance.
G. Treat insulated pipe in equipment rooms and where exposed to normal view, so surfaces may be painted with water base latex paint. Use of mastics, adhesives, or jacketing which cause "bleeding" is prohibited.

3.2 INSTALLATION OF PIPE AND EQUIPMENT COVERING

A. Where fiberglass or flexible tubular insulation is used on piping sized 2" and larger, insert a section of foamglass insulation at hanger or support points between pipe and metal shield for full length of shield to prevent crushing of insulation. Insulation thickness to be same as adjoining insulation. Where insulation passes through pipe hangers and across trapeze supports, 12" long metal saddles shall be used. On cold pipe, vapor barrier should be carried through the hanger and sealed.

END OF SECTION 220719
SECTION 221116
DOMESTIC WATER PIPING AND VALVES

PART 1 GENERAL

1.1 SYSTEM REQUIREMENTS

A. Submit pipe, valves, and fittings and have approved before starting installation. Pipe, valves, and fittings to be new, manufactured domestically, and marked clearly with manufacturers’ name, weight, and classification or working pressure.

B. Piping to run approximately as shown on drawings or as structural and architectural conditions permit.

C. All products used for dispensing potable drinking water must be lead free and meet the requirements of NSF 61 and NSF 372 test standards via third party testing and certification.

PART 2 PRODUCTS

2.1 COPPER PIPES

A. Type "L" hard-drawn seamless copper tubing, ASTM B-88: Domestic hot and cold water 4” O.D. and smaller.

B. Type "K" hard-drawn seamless copper tubing:
   1. Domestic water lines located under slab.
   2. Exterior domestic water lines 2-1/2” and smaller underground.
   3. Provide rolled, soft drawn type "K" seamless copper tubing for under slab and below grade where length of run between fittings exceeds maximum hard-drawn lengths.

C. Copper Pipe Fittings:
   2. Dielectric connection: Provide Epco Sales, lead free dielectric couplers at junction of steel pipe and equipment with copper piping systems. Use of steel or cast iron fittings in copper piping systems prohibited. T-drill branch tee connections shall not be allowed for domestic water piping.

D. Unions to be brass ground joint, 250-pound working pressure.

E. Nipples used in conjunction with copper pipe to be brass.
2.2 VALVES

A. Valves are specified by Manufacturer and Model Numbers to establish quality levels unless otherwise noted. Crane, Milwaukee, Hammond, Nibco, Stockham, Centerline, Apollo, Kitz, or Watts are considered equal manufacturers. Provide clamp lock hand lever operators on valves less than 8 inches. Provide hand wheel and closed housing worm gear on valves 8 inches and larger unless indicated otherwise below. Provide chain operators for all equipment room and powerhouse valves 4 inch and larger which are located over 6 feet 6 inches above the finish floor. All valves shall meet NSF-61 requirements.

1. Gate Valves:
   a. Gate valves for 2-1/2" and larger steel piping systems to be Class 125, cast iron body, bronze mounted, flanged ends, Nibco F-607-RW. Valves to have solid wedge disc, outside stem and yoke with rising stem, and bolted bonnet. Provide dielectric bolt protectors at all flanges when connecting dissimilar metals.
   b. Gate valves for copper piping 2" and smaller systems to be Class 125, bronze body, solder ends, Nibco S-113 LF. Valve to have either solid or split wedge disc, inside screw, non-rising stem, and screwed bonnet.

2. Globe Valves:
   a. Globe valves 2-1/2" and larger to be Class 150, cast iron body, bronze mounted, flanged ends, Watts M6115-74 lead free. Valves to have renewable seat and disc, outside stem and yoke with rising stem, and bolted bonnet.
   b. Globe valves 2" and smaller to be Class 150, bronze body, screwed ends, Apollo 121T-LF. Valve to be plug type with renewable seat and disc, rising stem, and union bonnet.

3. Ball Valves:
   a. Ball valves for copper water piping systems 2" O.D. and smaller to be equal to Apollo "3" S-585-66LF, solder ends, and for 2-5/8" thru 3-1/8" O.D. to be equal to Nibco T T-585-66LF, threaded ends. Valves to have bronze body, chromium plated bronze ball, PTFE seats, stuffing box ring and seals, and quarter turn on-off. Provide memory stops for valves used for balancing service. Valves to be rated for 400-psi WOG at 200 degrees F. Install threaded end valves with lead free brass adapters.
   b. Ball valves for copper water piping systems to be T-585-66LF threaded ends with bronze body chromium plated bronze ball, PTFE seats, stuffing box ring, and seals, and quarter turn on-off. Provide memory stops for valves used for balancing service. Valves to be rated for 400-psi WOG at 200 degrees F. Install threaded end valves with lead free brass adapters.

4. Butterfly Valves: Butterfly valves for steel water piping systems to be Crane Centerline Series 200, or approved equal industrial quality lug type with threaded holes. Valves to provide bubble-tight shut-off at 150 psi working pressure and 200 degrees F. Valves to have ductile iron body, "EPT" seats and stem seals, 316 stainless steel or bronze disc, 316 or 304 stainless steel stems. Valves 4" and larger to have weatherproofed sealed gear operator consisting of fully enclosed worm, worm gear, and worm shaft with handwheel to provide necessary torque for close-off and infinite throttling positions. Valves 3" and
smaller to have 10 position lever lock handle suitable for on-off and manual throttling service. All operators to have valve position indicator and memory stop.

5. Check Valves:
   a. Check valves for copper water piping systems to be swing type, Class 125, bronze body, screwed ends, Nibco T-413-Y-LF.
   b. Check valves for steel water piping systems to be Nibco-910 LF Silent Check Valve. Body to be iron with bronze disc plates. Stem to be 316 stainless steel, seat to be EPT. Valve to be suitable for 200 psi working pressure at 200 degrees F.

6. Flow balancing valves for domestic hot water service shall be Bell & Gossett lead free Circuit Setter Plus or approved equal. Valve shall provide flow balancing, flow measuring, and positive shutoff service. Provide valve with memory stop, capped differential pressure readout ports with internal check valves and preformed insulation. Valve construction to be bronze body and brass ball rated for 200 psig at 250 degrees F.

2.3 HANGERS

A. Non-insulated copper tubing 1/2" O.D. thru 4" O.D. with no longitudinal movement to be Grinnell Figure CT-99C, MSS SP-69 TYPE 9, plastic coated adjustable tubing ring hanger.

B. Insulated copper piping 1/2" O.D. thru 2-1/8" O.D. with longitudinal movement to be Grinnell Figure 171, MSS SP-69 TYPE 41, pipe roll complete with Figure 167, MSS SP-69 TYPE 40, galvanized steel insulation protection shield sized for maximum 10' span on 4 psi compressive strength insulation.

C. Support copper pipe risers by Grinnell Figure CT-121C, MSS SP-69 TYPE 8, plastic coated riser clamps at floor penetrations.

D. Support three or more parallel lines by trapeze hangers utilizing Unistrut channel or equal in bottom mounting arrangement with rod hanging support.

E. Adequately size hangers on insulated piping for insulation to pass continuously through hangers. Insulated piping to be supported outside insulation covering.

F. Provide concrete inserts, Grinnell Figure 282, MSS SP-69 TYPE 18, universal concrete insert, for attaching hangers to building structure. Inserts to be adequately sized and correctly positioned to support piping, valves, etc., when full of water and system is in operation.

G. Provide C-clamps with locknut, Grinnell Figure 86, MSS SP-69 TYPE 23, where piping is to be hung from steel beams. Welding hanger rods to steel members is not permitted. Provide malleable beam clamps, Grinnell Figure 218, MSS SP-69 TYPE 30, with extension piece, Grinnell Figure 157, where piping is hung from bar joist.

H. Attention is called to pipe spring isolation specified to be furnished by this Contractor.
I. Support all piping by heavy steel, adjustable hangers, or brackets suitably fastened to structural portion of building. Place hangers in accordance with following tables.

<table>
<thead>
<tr>
<th>COPPER TUBING SUPPORTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIZE (IN.)</td>
</tr>
<tr>
<td>5/8</td>
</tr>
<tr>
<td>7/8 - 1-1/8</td>
</tr>
<tr>
<td>1-3/8 - 2-1/8</td>
</tr>
<tr>
<td>2-5/8 - 5-1/8</td>
</tr>
<tr>
<td>6-1/8 - 8-1/8</td>
</tr>
</tbody>
</table>

J. Perforated metal, strap iron, or band iron hangers are not permitted. Offsets in hangers are not allowed. Pipe risers to be supported at regular intervals in pipe shafts within the limits of good practice.

K. See Insulation Section for requirements at pipe hangers.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install piping not to interfere with opening of doors or other moving parts. Do not install piping near or directly over any portion of electrical equipment.

3.2 FIRE-RATED PARTITIONS

A. Provide permanent firestop system at all piping penetrations of fire-rated walls and floors. Review details on drawing as well as this specification for permissible firestop systems. The firestop system shall have been tested and approved in accordance with ASTM E119 and U.L. 1479 (ASTM E814) and classified for up to 2 hours fire rating. Firestop system shall be type detailed on drawings or intumescent type capable of expanding up to 8 times its original volume. Firestop system to be 3M, Hilti, Nelson, Johns Manville, or Specified Technologies. Firestop system shall be installed in strict accordance with published U.L. approved installation instructions. Piping to pass through the fire-rated partition insulated or non-insulated as specified and detailed. Submit U.L. approved installation drawing for each type of penetration prior to construction.

3.3 NON-RATED PARTITIONS

A. Piping to pass through the walls insulated or non-insulated as specified. Wall should be finished to fit neatly around the piping. Firestopping is not required at non-rated partitions.
3.4 PIPE SLEEVES

A. Pipe sleeves shall be provided at non-rated partitions and floor penetrations. Pipe sleeves to be Schedule 40 or 18 gage steel. Sleeves to extend 1-1/2” in excess of partition depth on each side. Sleeves penetrating floors in wet areas, including all mechanical rooms, shall extend a minimum of 1 inch above the floor.

1. Piping requiring sleeves: Copper pipes thru masonry walls

B. Provide chromium-plated escutcheon plates for exposed uninsulated pipes projecting through floors or walls in finished spaces. Mechanical rooms and janitor closets are not considered "finished" spaces.

C. Hang piping so equipment, flanges, and connections do not bear weight of piping.

D. Adequately support vertical lines at their bases or by a suitable hanger placed in horizontal line near riser or by a base fitting set on pedestal.

E. Pipes not to be hung or supported by pumps. No torque to be applied to pumps by connecting pipes. After final pipe adjustments and initial operation of the pumps, this Contractor to recheck alignment of pumps and realign as required.

F. Run piping in straight lines; riser lines to be plumb with such offsets only as indicated or necessary. No sagging of lines permitted.

G. Unless otherwise shown on drawings, lines to be installed to drain to sumps or sewer.

H. Ream pipe after cutting to full bore. Remove foreign matter from inside of pipe before installing. Keep installed piping free from dirt and scale and protect open ends from foreign matter. Use temporary plugs or other approved methods of open end closure.

I. Threads to be right-hand, pipe standard, clean cut, full depth, and tapered. Joints to be made tight without caulking. Approved pipe joint lubricant to be used, applied in thin layer to the male thread only.

J. Install copper fittings with suitable flux. Type K copper pipe to be joined by means of suitable flux and silver or phos-copper.

K. Piping to have sufficient number of flanges or unions for convenient installation and removal of piping and equipment.

L. Remake or replace defective, leaking, or otherwise unsatisfactory joints or material. Peening, caulking, or doping of piping is not permitted.

M. Install piping to prevent stresses and strains to piping and hangers from expansion or contraction. Provision for proper loops, offsets, or expansion joints to be responsibility of Contractor. Make provision for servicing and removal of equipment without dismantling piping.
3.5 PIPING IN TRANSFORMER, ELECTRICAL, AND ELEVATOR EQUIPMENT ROOMS

A. Refer to drawings. No water piping permitted in transformer, electrical, or elevator equipment rooms.

3.6 VALVE ACCESS

A. Locate all shutoff and control valves for easy access and operation. Where valves must necessarily be located in enclosed spaces, they shall be provided with access panels of sufficient size for operation. Furnish these access panels to proper trades for installation.

END OF SECTION 221116
PART 1 GENERAL

1.1 WORK INCLUDED

A. This section includes requirements for:
   1. Shock absorbers.
   2. Trap primers.
   3. Equipment connection backflow device.
   4. Vacuum breakers.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers are indicated in subsequent paragraphs.

B. All products used for dispensing potable drinking water must be lead free and meet the requirements of NSF 61 and NSF 372 test standards via third party testing and certification.

2.2 SHOCK ABSORBERS

A. Acceptable Manufacturers: Josam, Wade, J.R. Smith, Precision Products, Zurn, or Sioux Chief.

B. Refer to drawings for placement and size of shock absorbers.

C. Access Covers: Minimum size 12” x 12” located for access to shock absorbers.

2.3 TRAP PRIMERS

A. Acceptable Manufacturers: Josam, Zurn, Wade, J.R. Smith or Precision Plumbing Products.

B. Construct trap primer valve of all bronze, chrome plated with removable operating parts, integral vacuum breaker, and gasketed access cover.

C. Access Covers: Minimum size 12” x 12” located for access to trap primers.
2.4  EQUIPMENT CONNECTION BACKFLOW DEVICE

A. Acceptable manufactures: McCann Engineering ASSE 1022 Backflow Preventer.

B. Must meet ASSE 1022

C. Provide the above referenced backflow device if beverage equipment does not have integral backflow device.

2.5  VACUUM BREAKERS

A. Wilkins model 420

PART 3 EXECUTION

3.1  INSTALLATION AND TESTING

A. Shock Absorbers:
   1. Install shock absorbers above ceiling, outside wall so access and maintenance can be performed without disturbing walls and non-liftouts ceilings.
   2. Install shock absorbers on all flush valves, solenoid valves and quick closing devices.
   3. Test and certify shock absorbers by plumbing and drainage institute.

B. Trap Primers: Trap primers to have approval of plumbing and drainage institute.

C. Equipment Connection Backflow device: Provide on all water lines feeding coffeemakers, ice machines and beverage dispensers.

D. Vacuum Breakers: Provide on water lines feeding equipment to protect against back siphonage of contaminated water.

END OF SECTION 221119
SECTION 221316
SANITARY WASTE AND VENT PIPING

PART 1 GENERAL

1.1 WORK INCLUDED

A. Submit pipe and fittings and have approved before starting installation. Pipe and fittings to be new, manufactured domestically, and marked clearly with manufacturers' name, weight, and classification or working pressure.

B. Piping to run approximately as shown on drawings or as structural and architectural conditions permit.

PART 2 PRODUCTS

2.1 PVC PIPE

A. Schedule 40 PVC DWV pipe, ASTM D-2665 solid wall Type 1, Grade 1. Schedule 40 DWV waste and drainage piping below grade ONLY. PVC piping not permitted within Boiler Room, Central Sterile or Food Prep/Dishwashing areas.

B. TYPE PSM SDR-35 PVC sewer pipe with gasket slip joints, ASTM D-3034. Outside gravity, underground sanitary sewer drainage, from 5'-0" outside building to connection to local sewer.

C. Fittings to match piping system. Fittings to have manufacturer's trademark permanently identified in accordance with MSS-SP-25. Supplier to include with submittal data certification that fittings and flanges have met requirements.

D. Joints for piping to be made with tetrahydrofuran solvent cement. Joints to be in accordance with manufacturer's recommendations.

E. Pipe, fittings, and cement to all be supplied by single manufacturer for entire project.

F. All solvent cements shall be low emitting VOC at 510 g/L or less.

2.2 HANGERS

A. Non-insulated PVC pipe 1/2" O.D. thru 4" O.D. with no longitudinal movement to be Grinnell Figure CT-99C, MSS SP-69 TYPE 9, plastic coated adjustable tubing ring hanger.

B. Support PVC pipe risers by Grinnell Figure CT-121C, MSS SP-69 TYPE 8, plastic coated riser clamps at floor penetrations.
C. Support three or more parallel lines by trapeze hangers utilizing Unistrut channel or equal in bottom mounting arrangement with rod hanging support.

D. Adequately size hangers on insulated piping for insulation to pass continuously through hangers. Insulated piping to be supported outside insulation covering.

E. Provide concrete inserts, Grinnell Figure 282, MSS SP-69 TYPE 18, universal concrete insert, for attaching hangers to building structure. Inserts to be adequately sized and correctly positioned to support piping, valves, etc., when full of water and system is in operation.

F. Provide C-clamps with locknut, Grinnell Figure 86, MSS SP-69 TYPE 23, where piping is to be hung from steel beams. Welding hanger rods to steel members is not permitted. Provide malleable beam clamps, Grinnell Figure 218, MSS SP-69 TYPE 30, with extension piece, Grinnell Figure 157, where piping is hung from bar joist.

G. Attention is called to pipe spring isolation specified to be furnished by this Contractor.

H. Support all piping by heavy steel, adjustable hangers, or brackets suitably fastened to structural portion of building. Place hangers in accordance with following.
   1. Steel Pipe Supports
      a. Size (in.): 1-1/4, Distance Between Supports (ft.) 8
      b. Size (in.): 1-1/2 Distance Between Supports (ft.) 10
   2. PVC and Cast Iron Supports: Support each fitting, at intervals of not more than 5 feet, and at least at each joint.

I. Perforated metal, strap iron, or band iron hangers are not permitted. Offsets in hangers are not allowed. Pipe risers to be supported at regular intervals in pipe shafts within the limits of good practice.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install piping not to interfere with opening of doors or other moving parts. Do not install piping near or directly over any portion of electrical equipment.

3.2 FIRE-RATED PARTITIONS

A. Provide permanent firestop system at all piping penetrations of fire-rated walls and floors. Review details on drawing as well as this specification for permissible firestop systems. The firestop system shall have been tested and approved in accordance with ASTM E119 and U.L. 1479 (ASTM E814) and classified for up to 2 hours fire rating. Firestop system shall be type detailed on drawings or intumescent type capable of expanding up to 8 times its original volume. Firestop system to be 3M, Hilti, Nelson, Johns Manville, or Specified Technologies. Firestop system shall be installed in strict accordance with published U.L. approved installation instructions. Piping to pass through the fire-rated partition insulated or non-insulated as specified and detailed.
Submit U.L. approved installation drawing for each type of penetration prior to construction.

3.3 NON-RATED PARTITIONS

A. Piping to pass through the walls insulated or non-insulated as specified. Wall should be finished to fit neatly around the piping. Firestopping is not required at non-rated partitions.

B. Provide chromium-plated escutcheon plates for exposed uninsulated pipes projecting through floors or walls in finished spaces. Mechanical rooms and janitor closets are not considered "finished" spaces.

C. Hang piping so equipment, flanges, and connections do not bear weight of piping.

D. Adequately support vertical lines at their bases or by a suitable hanger placed in horizontal line near riser or by a base fitting set on pedestal.

E. Pipes not to be hung or supported by pumps. No torque to be applied to pumps by connecting pipes. After final pipe adjustments and initial operation of the pumps, this Contractor to recheck alignment of pumps and realign as required.

F. Run piping in straight lines; riser lines to be plumb with such offsets only as indicated or necessary. No sagging of lines permitted.

G. Unless otherwise shown on drawings, lines to be installed to drain to sumps or sewer.

H. Ream pipe after cutting to full bore. Remove foreign matter from inside of pipe before installing. Keep installed piping free from dirt and scale and protect open ends from foreign matter. Use temporary plugs or other approved methods of open end closure.

I. Threads to be right-hand, pipe standard, clean cut, full depth, and tapered. Joints to be made tight without caulking. Approved pipe joint lubricant to be used, applied in thin layer to the male thread only.

J. Piping to have sufficient number of flanges or unions for convenient installation and removal of piping and equipment.

K. Remake or replace defective, leaking, or otherwise unsatisfactory joints or material. Peening, caulking, or doping of piping is not permitted.

L. Install piping to prevent stresses and strains to piping and hangers from expansion or contraction. Provision for proper loops, offsets, or expansion joints to be responsibility of Contractor. Make provision for servicing and removal of equipment without dismantling piping.
3.4 PIPING IN TRANSFORMER, ELECTRICAL, AND ELEVATOR EQUIPMENT ROOMS

   A. Refer to drawings. No water piping permitted in transformer, electrical, or elevator equipment rooms.

3.5 GRADES AND ELEVATIONS

   A. Uniformly grade sanitary drainage lines to elevations shown. If no elevations are given, pitch sewers not less than 1/8" per foot.

END OF SECTION 221316
SECTION 221319
SANITARY WASTE PIPING SPECIALTIES

PART 1 GENERAL

1.1 WORK INCLUDED

A. This section includes requirements for cleanouts.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers are indicated in subsequent paragraphs.

2.2 CLEANOUTS

A. Acceptable Manufacturers: Josam, Wade, J.R. Smith, or Zurn. The following model numbers listed are Zurn.

B. Exterior: ZN-1402-BP-HD cast iron cutoff ferrule with round nickel bronze scoriated frame and cover, secured.

C. Finished Concrete Floor: ZN-1400-HD-BP inside caulk round nickel bronze scoriated frame and cover.

D. Resilient Tile Floor: ZN-1400-X-BP inside caulk round nickel bronze scoriated frame and cover, secured.

E. Carpet: ZN-1400-CM-BP inside caulk round nickel bronze scoriated frame and cover; provide carpet marker and permanent marker in ceiling above.

F. Wall: ZN-1441-BP cast iron cleanout with bronze plug and round stainless steel cover.

G. Wall: Z-1446-BP cast iron cleanout with bronze plug and round stainless steel cover.

H. Access Covers: Minimum size 12" x 12" located for access to valves, shock absorbers, trap primers, wall cleanouts, etc.

I. Furnish cleanouts occurring in waterproof floors with clamping devices.
PART 3 EXECUTION

3.1 INSTALLATION AND TESTING

A. Cleanouts:
   1. Locate line size cleanouts, except 4" largest required, at base of all soil and waste stacks, at all changes in direction and in straight runs. Ensure spacing in straight runs does not exceed 50 feet inside building and 100 feet outside the building.
   2. Extend inaccessible cleanouts up through floor and/or wall provided easy accessibility cannot be obtained otherwise.

END OF SECTION 221319
PART 1 GENERAL

1.1 MANUFACTURERS

A. Provide plumbing fixtures and drains as listed on drawings and described herein. Fixture numbers are Kohler products. Equal fixtures by Zurn, American Standard, or Crane will be considered equivalents.

B. All drainage products to be Josam, Zurn, J.R. Smith, MIFAB, Wade or Watts. All drains installed above slab to be complete with clamping device.

C. Stainless steel sinks shall be Just, Elkay, or Kohler.

D. Flush valves shall be Zurn-AV or Sloan Royal, no exceptions.

E. Pressure balancing shower valves shall be Symmons, Leonard (Pam II), or Powers Hydro Guard T/P 700 series.

F. Commercial or public faucets shall be Zurn, Chicago Faucets, Symmons, Kohler, American Standard, or Speakman.

G. Gooseneck faucets shall be Zurn, Chicago Faucet, T & S, Kohler, American Standard, or Speakman.

H. Fixture supplies, stops, and traps to be commercial grade McGuire, E.B.C., Zurn, or approval equal. Traps to be 17 gauge with wall flange. Supplies and stops to be heavy pattern with wheel handle unless noted otherwise.

I. Water closet seats shall be Bemis, Church, Kohler, Beneke, or Olsonite.

J. Thermostatic mixing valves shall be Symmons, Holby, Powers, or Leonard.

K. China or enamel fixtures to be white color, unless otherwise noted.

L. All wall-mounted lavatories shall be capable of supporting a minimum vertical load of 250 pounds. Install wall-mounted lavatories with floor-anchored carriers which fit in standard stud walls.

M. All products used for dispensing potable drinking water must be lead free and meet the requirements of NSF 61 and NSF 372 test standards via third party testing and certification.
PART 2 PRODUCTS

2.1 FIXTURES

P-1  Water Closet - Public, Floor Mounted, Child Barrier-Free, 1.6 Gallon:
     Zurn Z5655 siphon jet bowl with 15” rim height
     Zurn Z5955SS-EL seat
     ROYAL 111 SFSM-1.6-HW (sensor-hardwired) flush valve

P-2  Water Closet - Public, Floor Mounted, 1.6 Gallon:
     Zurn Z5655 siphon jet bowl with 15” rim height
     Zurn Z5955SS-EL seat
     ROYAL 111 SFSM-1.6-HW (sensor-hardwired) flush valve

P-3  Urinal, Barrier-Free, 0.5 Gallon:
     Zurn Z5798 bowl
     ROYAL 186 SFSM-0.5-HW (sensor-hardwired) flush valve
     Install 17” from rim to finished floor

P-4  Urinal, 0.5 Gallon:
     Zurn Z5798 bowl
     ROYAL 186 SFSM-0.5-HW (sensor-hardwired) flush valve

P-5  Lavatory, Wall Hung, Barrier-Free, Public, 0.5 GPM, No Built-In Soap Dispenser:
     Bradley MF2949 (4 station) JUV-IRP-TMA-DS-WHT
     Moen 8886 metering faucet
     Wilkins Model 38-ZW3870-XL-T mixing valve
     Zurn ZH8822-XL-LR supplies
     Zurn Z8700 p-trap
     Zurn Z8946-3 trap wrap kit

P-6  Single Compartment Sink, Gooseneck Faucet (Rigid), 1.5 GPM:
     Elkay LRAD-2219 – 4” deep
     Zurn Z831C4-XL-18F
     Wilkins Model 38-ZW3870-XL-T mixing valve
     Zurn ZH8822-XL-LR supplies
     Zurn Z8748 offset strainer
     Zurn Z8702 p-trap

P-7  NOT USED

P-8  Service Sink:
     Stern-Williams SB-902BP (24”x24”x12”) with stainless steel caps, two tiling
     flanges, back panels
     Zurn Z843M1 faucet with vacuum breaker
     Provide in-line spring-loaded check stops

P-9  NOT USED
P-10  Floor Drain, Regular:
Zurn ZN-415S-DP-P-Y S strainer, nickel bronze top, trap primer, sediment bucket

P-11  Floor Drain, 12” Mechanical Room:
Zurn ZN-541-P, nickel bronze top, sediment bucket, trap primer

P-12  Hose Bibb, Interior:
Zurn Z1341-P34-PC polished chrome finished with vacuum breaker
Install 18” above finished floor

P-13  Wall Hydrant, Exterior:
Zurn Z-1310, non-freeze with vacuum breaker and stainless steel face
Install 18” above finished grade

P-14  Electric Water Cooler, Barrier-Free:
Halsey Taylor HTVZ8SS-WF with stainless steel finish
Zurn ZH8822 stop
Zurn Z8700 p-trap
Install with bubbler 30” above finished grade

P-15  Electric Water Cooler, Bottle Filling Station:
Halsey HTHB-HACG8SS-WF with stainless steel finish
Zurn ZH8822-XL stop
Zurn Z8700 p-trap
Install with bubbler 36” above finished floor

PART 3 EXECUTION

3.1  REQUIREMENTS

A.  Water closets shall be installed complete with wall carriers, wax rings, bolt caps, and flush valves (or float valves).

B.  Elevated vacuum breakers, where specified, shall be installed 7'-6” above the finished floor.

C.  Countertop sinks shall be installed complete with required mounting rim or clips.

D.  After installation, all fixtures shall be cleaned and labels removed. Where fixtures are in contact with walls, floors, or countertops, caulking shall be applied. Caulking shall be General Electric white silicon sanitary sealant.

E.  Water closets identified on plans as barrier free fixtures shall have the flush valves installed per American Disabilities Act. Flush valves shall have the handle installed on the wide side of the stall. Coordinate with the architectural drawings.
F. Non pre-fabricated showers shall have chloraloy 240 brand non-plasticized chlorinated polyethylene concealed waterproofing membrane .040 inch thick. Installation shall be per manufacturers recommendations.

G. At each floor drain installed above slab on grade, install a 36" x 36" apron equal to chloraloy 240 brand non-plasticized chlorinated polyethylene concealed waterproofing membrane, .040 inch thick, waterproofing membrane to be installed per manufacturers recommendations.

END OF SECTION 224213
PART 1 GENERAL

1.1 WORK INCLUDED

A. Provide all labor, materials, tools, and services for a complete installation of equipment and systems contained in contract documents.

B. Principal features of work included are:
   1. Heating, ventilating, and air-conditioning system.
   2. Control system including line and low voltage control wiring and conduit.
   3. Demolition of existing equipment, ductwork, and piping.
   4. Seismic bracing and anchorage for equipment, ductwork, and piping.

1.2 RELATED WORK

A. Electrical power and interlock and control wiring and conduit.

B. Kitchen equipment.

C. Laboratory equipment.

D. Field painting of equipment, ductwork, and piping.

1.3 GENERAL

A. The contract documents form a guide for a complete system. Provide all items necessary to provide a complete system but not specifically mentioned, such as hangers, transitions, offsets, and drains.

B. Layouts indicated on drawings are diagrammatical only. Coordinate exact location of equipment, ductwork, and piping to eliminate conflict with other divisions. Designer reserves right to make reasonable changes in location of equipment, ductwork, and piping prior to construction. Coordination drawings shall be submitted prior to any equipment/systems being installed to ensure that installation conflicts between trades are minimized.

C. Should Contractor find during progress of work that in his judgment existing conditions make desirable a modification, report such item promptly to Designer for instructions. Do not make deviations from contract documents without review of Designer.

D. Supervise all work with a competent mechanic specifically qualified in mechanical discipline.
E. Modifications to system or equipment shall be coordinated by General Contractor. Any associated increase of cost of utility service/feeds proposed by General Contractor or Subcontractor shall be the responsibility of the Contractor.

1.4 PERMITS
   A. Secure and pay for permits, licenses, and inspections for work under this division.

1.5 CODES
   A. Comply with all pertinent local, state, and national codes. Refer to Division 01.

1.6 STANDARDS
   A. Comply with all pertinent standards. This list is provided as a convenience to Contractor and is not to be considered all inclusive.
      2. American Gas Association (AGA).
      3. Air Moving and Conditioning Association (AMCA).
      5. American Society of Mechanical Engineers (ASME).

1.7 SUBMITTALS
   A. Submit for review complete brochures and shop drawings for materials and equipment proposed in accordance with Division 01.
      1. Brochures: Submit complete descriptions, illustrations and specification data for materials and equipment proposed. Clearly indicate proposed items when other items are shown on same sheet. Submit samples on request and/or set up for inspection. Samples will be returned to Contractor.
      2. Submittals shall be submitted in line by line format. Each submittal shall be provided with a cover letter and supporting documentation indicating how the submittal meets each line of the referenced specification section. All discrepancies between the construction documents and the submitted product shall be clearly identified for engineer evaluation.
      3. If a product other than the basis of design is rejected by the engineer for any reason, the Contractor shall provide the basis of design product at no additional cost to the Owner.
      4. Shop Drawings:
         a. Control systems.
         b. Complete equipment, ductwork, and piping systems in equipment rooms.
         c. Complete equipment, ductwork, and piping systems in entire building.
         d. Underground steam distribution and chilled water system.
         e. Owner furnished equipment rough-in layouts.
         f. Kitchen hood and grease exhaust ductwork systems.
         g. Firestop systems.
B. The contractor shall be responsible for submitting signed copies of completed prefunctional, startup checklists on all equipment installed under Division 23 (i.e., pumps, boilers, air handlers, VFDs, etc.) prior to the start of any TAB fieldwork on that piece of equipment. If aforementioned equipment has been started up by a factory service technician, then copies of the service technician's startup checklists shall also be submitted.

1.8 PROJECT MAINTENANCE MANUALS

A. Prior to final acceptance of project, provide Owner with bound maintenance manuals in accordance with Division 01.

B. Prior to substantial completion of project, provide Owner with bound maintenance manuals in accordance with Division 01. The preliminary O&M manuals shall be submitted thirty (30) days after final submittal approval.

1.9 PROJECT TECHNICAL INSTRUCTION

A. Prior to final inspection of project, provide technical instruction to Owner as follows:
   1. Field Instruction: Provide explanation of how systems and equipment are to operate during each season and during emergencies.
   2. Field Demonstration: Demonstrate operation and routine maintenance for systems and equipment.
   3. Video: Provide digital video of all field instruction and demonstration to Owner at completion.

1.10 PROTECTION

A. Protect all materials and equipment in accordance with Division 01.

B. The contractor must take appropriate precautions, during construction, to prevent unnecessary dust and debris from getting into air and water handling systems by covering equipment, controls and open-ended ducts and pipes as the installation progresses.

1.11 CONSTRUCTION RECORD DOCUMENT

A. Provide construction record documents in accordance with Division 01. Keep at the project one set of drawings and daily record changes at the time they are made. Give drawings to Owner at project completion.

B. The contractor shall maintain an appropriate maintenance log, where applicable, of all interim maintenance tasks performed on all started-up equipment, so that the manufacturer's warranties are not voided prior to the equipment being turned over to the Owner. This log shall be submitted when the equipment is officially released to the Owner.
1.12 EXISTING SERVICES

A. Maintain existing services in operation during construction. Coordinate and schedule all service interruptions with Owner.

1.13 OWNER NOTIFICATION

A. Notify Owner two weeks prior to activation of central chilled water and steam service to project.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Provide materials and equipment of domestic manufacture bearing the U.L. label when such label is available.

PART 3 EXECUTION

3.1 COORDINATION

A. Coordinate work in accordance with Division 01. Coordinate locations of equipment, ductwork, and piping to eliminate conflict with other divisions.

B. Carefully examine contract documents to be thoroughly familiar with items which require plumbing or mechanical connections and coordination.

C. Provide proper chases and openings. Place sleeves and supports prior to pouring concrete or installation of masonry.

3.2 CUTTING AND PATCHING

A. Repair or replace routine damage caused by cutting in performance of contract.

B. Correct unnecessary damage caused due to installation of mechanical work.

C. Perform repairs with materials that match existing in accordance with the appropriate section of these specifications.

3.3 FLASHING, COUNTERFLASHING, AND SEALING

A. Flash, counterflash, and seal ductwork and piping at penetrations of roofs and outside walls.
3.4 TRENCHING, EXCAVATION AND BACKFILLING

A. Provide trenching, excavation, and backfilling necessary for performance of mechanical work accordance with Division 02.

B. Trenching and excavation of rock to be as described in Division 02.

C. Excavate to a depth at least 6" below bottom of pipe and a minimum of 36" above top of pipe. Fill below pipe, around pipe, and minimum of 12" above pipe with sand or Class "B" crushed stone tamped firm and even. Provide topsoil for final layer of dirt (12" minimum). Provide 6" spacing between pipes and between pipe and trench sides. Hand-grade with batterboards placed every 25'. Backfill by hand. Do not use rock or stone above sand or Class "B" crushed stone.

3.5 CONNECTION TO EQUIPMENT

A. Rough-in and connect to sterilizers, lab equipment, kitchen equipment, and Owner furnished equipment and provide a shutoff valve and union at each connection. Provide steam strainer and steam trap for steam equipment. Operating valves and/or controls for this equipment will be provided as an integral part of the equipment. Do not rough-in until shop drawings showing rough-in locations have been reviewed by Designer.

3.6 FOUNDATIONS AND PADS

A. Provide foundations, pads, and bases required for equipment. Concrete to be in accordance with concrete division of specifications.

B. Coordinate proper sizes and locations of foundations, pads, bases, anchors, supports, and other items to be built into structure.

3.7 IDENTIFICATION

A. Identify exposed or accessible piping with stenciling contents indicating pipe contents and direction of flow on piping not more than 20 feet apart, at valves, at access panels, and at least once above each space.

B. Contractor’s option to identify exposed or accessible piping with snap-on or strap-on type markers. Color code markers in accordance with ANSI. Indicate pipe contents and direction of flow on marker. Install markers on piping not more than 20 feet apart, at valves, at access panels, and at least once above each space.

C. Color code piping exposed in equipment rooms in accordance with the following schedule. Paint to be Sherwin Williams Metaltex or approved substitute.
   1. Chilled water - pale green.
   2. Hot water - pink.
   4. Steam - dark orange.
   5. Steam condensate - light orange.
D. Include design operating pressures in psig for steam and compressed air services.

E. Control compressed air and buried lines need not be marked.

F. Identify all mechanical equipment with engraved brass, aluminum, or stainless steel nameplates or tags. Use equipment names and numbers appearing in schedules on drawings. Fasten nameplates to equipment using screws. Glue or adhesive is not acceptable. Fasten tags to equipment using brass, aluminum or stainless steel chains.

G. Identify each valve with engraved brass, aluminum, or stainless steel identification tag indicating valve service and sequential identification number. Attach tag to valve handle with brass, aluminum or stainless steel chain. Provide two bound manuals to Owner listing each valve sequentially and indicating valve manufacturer, style, size, service, normal position, and specific location for each valve.

H. Frame and mount control diagrams and sequences in each equipment room. Use non-fading black and white prints encased in aluminum frame with Plexiglas cover.

3.8 CLEANING

A. Thoroughly clean ductwork and equipment casings before fans and filters are operated.

B. Repair damaged factory finishes covering all bare places and scratches.

C. Cleaning HVAC Systems Water Piping:
   1. Clean all equipment and piping of iron cuttings and other foreign matter as they are installed.
   2. Thoroughly flush HVAC water systems with precleaning chemicals designed to remove depositions such as pipe dope, oils, rust, mill scale, and other extraneous materials. Provide dosages of precleaner chemicals recommended by water treatment supplier and add and circulate throughout the water systems. Drain, refill, and flush water systems thoroughly until no foreign matter is observed and total alkalinity of the drain water is equal to that of the make-up water.
   3. Do not install devices in which foreign matter could become lodged, such as control valves, until cleaning and flushing are completed. Position valves to bypass chiller, boiler and heat exchanger. Connect supply and return runouts together at each coil location. Make connection of supply and return runouts with short lengths of high pressure rubber hose and brass fittings. One fitting shall be swivel type to eliminate turning fitting in hose.
   4. Fill system at City water make-up connection with all air vents open. After filling, close vents.
   5. Start main pump with pressure reducing valve makeup open. Check vents in sequence to bleed off any trapped air in order to assure circulation through all components of system. Verify pumps are properly aligned and bolted down before start-up to prevent damage to seals or couplings. Circulate water for at least two hours and then drain completely to flush out foreign matter.
   6. Remove, clean, and replace all strainer baskets. Clean all dirt legs. If indications are found of excessive dirt, repeat the above flushing.
7. Fill the system with fresh water, adding precleaning chemicals designed to remove depositions such as pipe dope, oils, rust, mill scale, and other extraneous materials. Provide dosages of precleaner chemicals recommended by water treatment supplier. Alternate operation of primary and standby pumps, and circulate the cleaning solution for 24 hours. Then turn off the pump and completely drain the system.

8. Remove, clean, and replace all strainer baskets. Clean all dirt legs. Replace suction diffuser start-up strainer with conventional strainer. Refill the system with clean water, venting all high points and equipment of air and gases. Bring water systems to operating temperature. Recheck all vent points during this process and remove all air.

9. After the system has been completely cleaned, test system by litmus paper or other dependable method and leave system on slightly alkaline side (ph 7.5 to 8.5). If system is still on acid side (ph 7.0 or lower), add water conditioner.

D. Cleaning Steam Supply and Steam Condensate Return Systems: Thoroughly clean using 5 psig steam allowing condensate to be wasted to drains for 8 hours.

3.9 TESTING

A. Test all installed equipment and systems and demonstrate proper operation. Correct and retest work found defective when tested.

B. Thoroughly check piping system for leaks. Do not add any leak-stop compounds to the system. Make repairs to piping system with new materials. Peening, doping, or caulking of joints or holes is not acceptable.

C. Conduct air or smoke test if in opinion of Designer reasonable cause exists to suspect leakage or low quality workmanship.

D. Test compressed air piping with Nitrogen at 100 psi for two hours without leaks.

E. Test HVAC systems water piping and steam supply and steam condensate return piping at a water pressure of 125 psig for two hours without leaks.

F. Vibration Tests:
   2. Verify all vibration isolation systems are free floating and not short circuited by any connection between equipment and building structure.
   3. Operate mechanical systems and verify visually and audibly that there is no excessive vibration or noise generated by the system.

G. The results of all piping system pressure tests shall be submitted to the construction manager.
3.10 SYSTEM TESTING, ADJUSTING, AND BALANCING (TAB)

A. Procure services of an independent testing, adjusting, and balancing agency to test, adjust, and balance mechanical systems. Submit TAB agency for review. Provide references of at least five completed projects of similar size and scope. TAB agency to be certified member of Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB).

B. Begin TAB after system has been completed and is in full working order. Place mechanical systems into operation and continue operation during each working day of TAB. Work performed by TAB agency to be under direct supervision of qualified TAB technician. Accurately calibrate and maintain in good working order instruments used in performance of TAB.

C. Air System Testing, Adjusting, and Balancing:
   1. Set controls so air terminal units are operating at maximum design airflow.
   2. Verify proper fan rotation.
   3. Adjust fan RPM to design requirements.
   4. Record rated and actual motor full load amps.
   5. Make pitot tube traverse of main ducts and obtain design CFM at fans.
   6. Record system suction and discharge static pressures.
   7. Adjust system for design CFM supply air.
   8. Adjust system for design CFM return air.
   9. Adjust system for design CFM outside air.
  10. Adjust system for design CFM exhaust air.
  11. Verify maximum and minimum supply cfm for each air terminal unit and adjust as required to design cfm.
  12. Adjust each air device to within 10% of design cfm. Adjust air devices to minimize drafts and noise. Identify each air device location and area served.
  13. After adjustment of air terminal units and air devices, recheck fan cfm, static pressures, and motor full load amps.
  14. Record design, initial, and final readings for each fan, air terminal unit and air device.
  15. As recommended by TAB agency, Contractor to make changes in fan drives and add balancing dampers at no additional cost to provide proper balance.

D. Water System Testing, Adjusting, and Balancing:
   1. Open valves to full open position. Set mixing valves to full coil flow.
   2. Set controls so coils are operating at maximum design water flow.
   3. Verify proper pump rotation.
   4. Examine water system and determine if system has been treated and cleaned as previously specified.
   5. When determined system water is clean, charge expansion tank.
   6. Set pumps to design gpm. Pump manufacturer to trim pump impellers as necessary to set pump to design gpm at actual head.
   7. Record pump suction, discharge, and total head.
   8. Record rated and actual motor full load amps.
9. Check and set operating temperatures of chiller, boiler and heat exchanger to design requirements.
10. Adjust each chiller, boiler and heat exchanger to within 10 percent of design gpm.
11. Check water temperatures at inlet side of coils. Note rise or drop of temperature from source.
12. Adjust each zone and coil to within 10 percent of design gpm using flow balancing and measuring devices. Set pressure drop across coil bypass to match coil pressure drop.
13. After adjustment of zones and coils, recheck settings at pumps, chillers, boilers and heat exchangers.
14. Record design, initial, and final readings for each pump, chiller, heat exchanger zone, and coil.

E. Perform work, record data, and submit complete TAB report to Designer for review upon completion.

F. Designer may request a recheck or resetting of any item listed in report. Provide tests Designer may request.

G. Designer will accept job on basis of tests and inspections. A representative of TAB agency and control system manufacturer is to be in attendance to assist final inspection. Furnish necessary mechanics to operate system, make any necessary adjustments, and assist with final inspection. In addition to requirements of Division 01, complete the following before requesting a final inspection.
1. Work required under this division of specifications.
2. System testing, adjusting, and balancing.
3. Control system commissioning.
4. Furnish required project maintenance manuals and control diagrams and sequences.

END OF SECTION 230100
PART 1 GENERAL

1.1 WORK INCLUDED

A. Work required under this section of the specifications consists of basic materials and methods applicable to work under Division 23.

PART 2 PRODUCTS

2.1 VIBRATION ISOLATION

A. Isolate equipment as shown on drawings and as specified herein with factory-fabricated vibration isolators in accordance with recommendations in the latest edition of ASHRAE Applications Handbook. Isolators shall be manufactured by Kinetics, Mason Industries, or approved substitute. Provide isolators by a single manufacturer. Provide isolators of proper sizes and weight loading to meet the requirements. Provide isolators as floor-mounted fiberglass or neoprene rubber pads, Kinetics Model KIP.

1. Floor-mounted fiberglass or neoprene rubber pads, Kinetics Model KIP.

2.2 V-BELT DRIVES

A. Provide all fan drives with V-belts rated for 150% of nameplate motor horsepower. Provide adjustable pitch motor sheaves for motor sizes through 20 hp. For motor sizes 25 hp and larger provide fixed pitch motor sheaves after balancing to within plus 5% of design air quantity. Select motor sheaves so centerline does not extend past end of motor shaft and such that motor bearing grease fitting and relief port is not obstructed.

B. Provide belt guards for all belt driven equipment. Provide expanded metal cover with access to driven shaft for tachometer.

2.3 FOUNDATIONS AND PADS

A. Provide foundations, pads, and bases required for equipment. Concrete to be in accordance with concrete division of specifications.

B. Coordinate proper sizes and locations of foundations, pads, louvers, anchors, supports, and other items to be built into structure.

2.4 FASTENINGS TO STRUCTURES

A. Provide structural fastening devices for equipment, materials, piping and ductwork. Devices to be concrete inserts, expansion shields and lag bolts, and through bolts-
washers-nuts. All bolted devices to use jamb nuts. Inserts to be continuous type as manufactured by Unistrut or approved substitute. Install per manufacturer's published installation instructions in lengths to suit specific application, complete with spring nuts, end caps, and plastic coated filler to prevent concrete seepage.

B. Use of power drive "shot-pins" is permitted only for ducts 20" in width and smaller and single pipes 1" and smaller.

2.5 ACCESS PANELS

A. Provide ceiling and wall access panels for installation by other Divisions. Coordinate locations so panels will provide proper access to equipment served. Notify Designer of proposed wall or ceiling access panel locations prior to installation of such panels. Minimum size: 24" x 24".

B. Panels shall be manufactured by Bilco or approved substitute. Provide panels with minimum 16 gauge steel construction with screwdriver operated locks and primer finish.

C. Provide fire-rated panels for installation in fire-rated partitions.

PART 3 EXECUTION - NOT APPLICABLE

END OF SECTION 230549
PART 1 GENERAL

1.1 WORK INCLUDED

A. Perform test and balance work by a Test and Balance Agency which is engaged solely in full time test and balance work, is a member of the Associated Air Balance Council (AABC), National Environmental Balancing Bureau (NEBB) or approved equal, and is selected and employed by the contractor.

B. Perform test and balance in accordance with AABC or NEBB Standards.

C. Contract to the Test and Balance Agency shall be issued by the contractor. Coordination with the agency at the job site shall be the responsibility of the contractor in order to ensure proper scheduling and operation of the systems. All correspondence (reports, letters and communications) between any parties shall have copies sent directly to the designer and contractor.

D. The TAB agency shall review construction plans and specifications. If any discrepancies are noted which would hinder balancing, notify the designer with copy to the contractor. Make inspections of the job during construction for proper installation of the system(s) and of balancing aids in the system(s). Any discrepancies noted shall be brought to the attention of the contractor and designer. The number of inspections vary with the size and complexity of the job and shall be adequate for the purpose intended. Report ALL job visits in writing -MANDATORY.

E. The TAB agency shall work in close coordination with the contractor in calibrating all airflow and water flow stations and all duct and pipe mounted differential pressure sensor / transmitters. The tests shall be documented and included in the final TAB report.

F. The TAB agency shall provide one (1) technician with full instrumentation for the purpose of verifying the data submitted in the final TAB report. If 10 percent or more of the retested items are found to be plus or minus 10 percent or more out-of-tolerance of published final TAB report values, then the TAB agency shall be liable for retesting part or all of the specific HVAC system before undergoing further performance verification. However, all out-of-design-tolerance values identified shall be reported, and corrected by the construction team.

1.2 RESPONSIBILITIES OF PROJECT CONTRACTOR

A. The contractor shall:
   1. Provide approved Test and Balance Agency with copy of plans and specifications upon issue of construction documents.
2. Have the building and HVAC systems in operational readiness for TAB work to begin.
3. Correct prompt deficiencies of materials and workmanship identified as delaying completion of TAB work.
4. Be responsible for any added costs to the owner resulting from his failure to have the building and HVAC systems ready or from his failure to correct deficiencies promptly.

B. Complete operational readiness of the building requires that construction status of the building shall permit closing of doors, windows, ceilings installed, etc., to obtain projected operating conditions.

C. Complete operational readiness of the air conditioning systems requires that the following be accomplished:
   1. Air Distribution Systems:
      a. Verify installation conforms to design. All supply, return and exhaust ducts terminated and pressure tested for leakage as required by specifications.
      b. All volume, control, fire and smoke dampers properly located and functional. All dampers shall be fully open. MVD gradients and spin damper handles should be exposed through insulation. Dampers serving requirements of minimum and maximum outside, return and relief air shall provide tight closure and full opening, smooth and free operation.
      c. All supply, return, exhaust and transfer grilles, registers, diffusers, and filters installed.
      d. Air handling systems, units and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., shall be sealed to eliminate bypass or leakage of air.
      e. All fans operating at full load and verified for freedom from vibration, proper fan rotation and belt tension; heater elements in motor starters to be of proper size and rating. Check motor amperage and verify that it is under nameplate rating.
   2. Water Circulating Systems:
      a. Check and verify pump alignment and rotation. Verify location of thermometers, gages, and PT test plugs.
      b. Open all valves to full open position. Close bypass stop valves. Set mixing valves to full flow through system components. Remove and clean all strainers. Verify specified pipe cleaning has taken place. Repeat operation until circulating water is clean.
      c. Record pump motor amperage on each phase and voltage after reaching rated speed. Readings shall not exceed nameplate rating. Verify heater elements in motor starters to be of proper size and rating.
      d. All water circulating systems shall be full and free of air; expansion tanks set for proper water level; all air vents installed at high points of systems and operating freely. System static pressure to be set minimum 5 psig above highest system elevation.
      e. Check and set operating temperatures of heat exchangers to design requirements.
f. Verify that piping to coils is complete and set for counter flow. Verify location of thermometers, gauges, PT test plugs, and flow balancing/measuring valves.

3. Automatic Controls:
   a. Verify that all control components are installed and functional in accordance with project requirements, including all electrical interlocks, damper sequences, temperature resets, and safeties.
   b. Verify that pressure controllers are calibrated and control variable speed motor controllers as required to maintain a stable pressure.
   c. All controlling instruments calibrated and set for designed operating conditions.

4. Notification of System Readiness: After completion of the work above, the contractor shall notify the TAB firm and designer certifying that the work has been accomplished and that the building and HVAC systems are in readiness for testing, adjusting, and balancing.

D. As part of this project contract, the contractor shall make any changes in the sheaves, belts and dampers required for correct balance as required by the TAB firm.

E. The contractor shall provide and coordinate services of qualified, responsible contractors, suppliers and personnel as required to correct, repair, or replace any and all deficient items or conditions found during the testing, adjusting and balancing period.

F. In order that all systems may be properly tested, balanced, and adjusted, the contractor shall operate systems at his expense for the length of time necessary to properly verify their completion and readiness for TAB.

G. Project schedules shall provide sufficient time to permit the completion of TAB services prior to owner occupancy.

H. The plans and specifications have indicated valves, dampers and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions, and it will be the responsibility of the contractor to install these devices in a manner that will leave them accessible and readily adjustable. Should any such device not be readily accessible, the contractor shall provide access as requested by the TAB firm. Also, any malfunction encountered by TAB personnel shall be reported to the contractor and designer and corrected by the contractor immediately so the balancing work can proceed.

I. The TAB fieldwork shall not begin on any system / equipment item until signed prefuctional, startup checklists, pertaining to applicable equipment, have been submitted by the installing contractor to the owner.

J. The TAB agency shall be provided with either appropriate control system software or the contractor's handheld device for setting the terminal boxes and entering / updating terminal box flow coefficients, and for placing equipment in the correct mode for testing. This software and/or equipment shall be provided to the TAB agency free of charge for the duration of the project, and shall be returnable to the contractor upon
completion of the project. Providing the TAB agency laptop software for placing equipment in the proper operating mode for testing, and for entering terminal box flow coefficients, allows the TAB agency to program the boxes as it completes them, and is the most effective use of both the contractor's and TAB agency's time.

1.3 QUALIFICATIONS OF THE TAB CONTRACTOR

A. The firm shall submit six (6) completed projects of like size and scope. Provide references for each project.

B. The test and balance firm shall submit a resume for the individual proposed to directly supervise the project. The supervisory personnel for the test and balance firm shall be certified test and balance engineers. All project managers and technicians shall be permanent, full-time employees of the agency.

C. The test and balance firm shall submit a list of its calibrated instrumentation to perform the work.

1.4 DOCUMENTS

A. The contractor shall furnish to the TAB firm the following:
   1. One set of mechanical specifications.
   2. Three sets of mechanical drawings.
   3. All pertinent addenda and change orders.
   4. One set of control submittal drawings.
   5. Approved submittal data on equipment installed, and related changes as required to accomplish the TAB test procedures outlined below.

PART 2 PRODUCTS – NOT APPLICABLE

PART 3 EXECUTION

3.1 RESPONSIBILITIES OF THE TAB FIRM

A. The TAB personnel shall check, adjust, and balance the components of the HVAC system which will result in minimum noise, specified temperature, and air flow conditions in the conditioned spaces of the building while the equipment of the system is operating economically. This is intended to be accomplished after the system components are installed and operating as provided for in the contract documents.

3.2 LIAISON AND EARLY INSPECTION

A. The personnel on the job shall act as liaison between the owner, designer and contractor. They shall inspect the installation of piping systems, ductwork systems, control systems, and other component parts of the HVAC systems during the construction stage to verify proper arrangement and adequate provisions for the testing and balancing.
B. During the balancing process, as abnormalities and malfunctions of equipment or components are discovered by the TAB personnel, the contractor shall be advised in writing so that the condition can be corrected by the contractor. The TAB firm shall suggest solutions to noted problems. Data from malfunctioning equipment shall not be recorded in the final TAB report.

3.3 THE TAB REPORT

A. TAB activities shall culminate in a report to be provided in triplicate to the designer. The intent of the final report is to provide a reference of actual operating conditions for the owner's operating personnel.

B. All measurements and recorded readings (of air, water, electricity, sound, etc.) that appear in the reports must be done on-site by permanently employed technicians or engineers of the firm.

C. All comment sheets (punch lists) shall be signed by the contractor to acknowledge receipt. Any outstanding items at the time of completion shall be included in the report.

D. The report shall be certified and approved by the firm's test and balance engineer. The report shall be recorded on standard forms.

3.4 ACTUAL TESTING AND BALANCING PROCEDURES

A. Airside:
   1. Supply Air:
      a. Fans checked for rotation, amperage, static pressure, etc.
      b. Main supply duct pitot tube traverse and adjustment of fan speed to produce design cfm while maintaining minimum system static pressure for proper terminal box operation.
   2. Return Air:
      a. Fans checked for rotation, amperage, static pressure, etc.
      b. With supply system in the maximum mode, traverse and adjust return fan to design cfm.
      c. With supply system in the maximum mode, proportion return inlets to within 5% of design cfm.
   3. Outside Air:
      a. Fans checked for rotation, amperage, static pressure, etc.
      b. With supply system in the maximum mode, traverse and adjust minimum outside air damper and/or fan to design cfm.
   4. Exhaust Air:
      a. Fans checked for rotation, amperage, static pressure, etc.
      b. With supply system in the maximum mode, traverse and adjust exhaust fan to design cfm.
      c. Proportion exhaust inlets to within 5% of design cfm.
5. Diffusers, Registers, and Grilles:
   a. Balance each supply, return and exhaust air outlet within 5% of design cfm.
   b. Check and/or adjust pressure relationships so that each positive pressure and each negative pressure area is at least 10% positive or negative as appropriate.

6. After completion, take total air-handling system static profile and record all final statics, amperages, rpm, cfm, etc.

B. Waterside:
   1. Chilled Water:
      a. Check system for cleanliness.
      b. With all chilled water valves calling for full cooling, test, set and record each pump head and flow.

   2. Condenser Water:
      a. Check system for cleanliness.
      b. With strainers clean and all valves wide open, test, set and record each pump head and flow.
      c. Balance hot water basins in tower for even distribution.
      d. Test, set and record pressure drop and flow through each chiller.
      e. Verify removal of pump start-up strainer and replacement with operating strainer.

   3. Domestic Hot Water Recirculation System:
      a. Balance recirculation pumps ±5% of design gpm flow.
      b. Set balancing valves to gpm settings as noted on plumbing drawings.

C. Controls:
   1. AHU Controls:
      a. Check temperature controls for proper calibration and setpoint.
      b. Check economizer controls for proper damper operation and control calibration.
      c. Check supply/return volumetric synchronization system under maximum and minimum conditions for proper operation.
      d. Check static pressure control under maximum and minimum conditions for proper operation.

   2. Thermostats and Controllers:
      a. Check for proper control of valves, dampers, terminal boxes, exhaust fans, etc.
      b. Set at design set point.

D. Capacity and Performance Test:
   1. Cooling Coils:
      a. Test, set and record pressure drop and flow through each coil.
      b. Measure entering and leaving dry and wet bulb air temperatures with glass stem, mercury thermometers accurate to 1/2 degrees F.
      c. Measure entering and leaving water temperature with glass stem, mercury thermometer if thermometer wells are provided. If P.T. plugs are provided, use a bi-metal thermometer which reads in 1 degree F. increments and use the same thermometer for both supply and return water temperature measurements.
d. Record final temperatures, BTU/HR. and GPM.
e. Convert actual test conditions to design conditions to insure design coil capacities at design temperatures.

2. Heating Coils (Air Handling Unit and Preheat Only):
   a. Test, set and record pressure drop and flow through each coil.
   b. Measure entering and leaving dry and wet bulb air temperatures with glass stem, mercury thermometers accurate to 1/2 degrees F.
   c. Measure entering and leaving water temperature with glass stem, mercury thermometer if thermometer wells are provided. If P.T. plugs are provided, use a bi-metal thermometer which reads in 1 degree F. increments and use the same thermometer for both supply and return water temperature measurements.
   d. Record final temperatures, BTU/HR. and GPM.
   e. Convert actual test conditions to design conditions to insure design coil capacities at design temperatures.

3. Thermostat Calibration:
   a. Measure and record dry and wet bulb temperatures at each thermostat.
   b. Report any thermostat which is not controlling with +/-1-1/2 degree F.

4. Control Temperature Readouts:
   a. Test actual temperature next to sensor (if possible) and compare to readout.
   b. Report any sensor which is not within +/-1/2 degrees F.

E. Noise Level: The TAB Contractor shall measure the HVAC background noise level in all the spaces as follows: HVAC system produced noise shall not exceed the following levels: patient rooms, nurses stations, offices, conference rooms, LDRs, nursery, exam rooms, therapy rooms, diagnostic rooms, waiting rooms, and treatment rooms shall not exceed a NC 37; operating rooms, C-section rooms, lobbies, cafeteria, toilets, laboratories, and utility rooms shall not exceed a NC 42. NICU is NC 34.

F. The General Contractor and the Mechanical Contractor shall be responsible for reviewing the NC curve for spaces which exceed the required levels and make appropriate adjustments to the system to bring the NC level into range. The final TAB report shall document all spaces with appropriate NC levels.

3.5 REPORTS

A. Problems Encountered: Any items not installed, improperly installed or not functioning properly shall be reported to the contractor.

B. Final Report:
   1. Any unresolved problems shall be reported in a general remarks section in front of the test and balance report.
   2. Any unusual operations or pertinent remarks which may aid the maintenance personnel or ease the reading of the report shall be made in the general remarks section of the report.
   3. All operating data and final tests shall be reported in the final report. This data shall include, but not necessarily be limited to the scope of work outlined above.
4. TAB contractor shall compile an Excel spreadsheet for all terminal boxes, listing each box by its unique identification number, the inlet flow area established by the box manufacturer, the manufacturer’s gain factor for the box, final TAB calibrated gain factor for the box if field calibrated, and the ratio of the calibrated gain factor to the manufacturer’s gain factor.

5. Preliminary copies of the final TAB report shall be made available to the Cx team at the completion of the TAB fieldwork for the TAB performance verification phase of the Cx procedures.

C. Problems Encountered: Copies of the TAB agency generated deficiency reports shall be submitted to the Cx team to ensure that the appropriate installing contractors, and the design professional (i.e., A/E, for design related issues) have received copies of the reports, and to help ensure that immediate attention can be given to addressing and resolving the various deficiencies identified. No retesting of submitted deficiency items should be attempted by the TAB agency until signed copies of the deficiency reports, certifying completion of the item, have been received back from the applicable installing contractor.

3.6 CALLBACK

A. Test and Balance Agency shall retest any unresolved problems noted in the final report. The revised results shall be forwarded after completion of test.

B. At the discretion of the designer before final acceptance of the TAB report, the report data shall be verified one time on the job site by selection of random check points in the presence of the designer. Representatives of the testing firm shall be present and provide the necessary equipment for test data verifications.

C. The firm shall be responsible for testing, adjusting, balancing, and reporting on the performance of all fans, dampers, air distribution devices, pumps and heat exchangers, the flow through all coils, pumps and heat exchangers, and the power consumption of all motors. The contractors and the suppliers of the equipment installed shall cooperate with the balancing agency to provide all necessary data on the design and proper application of the system components and shall furnish all labor and material required to eliminate any deficiency.

D. Make one (1) inspection within ninety (90) days after occupancy of the building to insure that satisfactory conditions are being maintained.

3.7 OPPOSED SEASON TESTING

A. This service allows for testing of equipment that, due to extreme weather conditions, cannot be accurately tested at the time of the initial balance. If a project is balanced during the summer, the opposed season testing is performed during the winter months and vice-versa.

B. During the opposed season testing, any necessary modifications to the initial adjustment required to produce optimum operation of the system components shall be made to produce the proper seasonal conditions in each conditioned space. At the
time of opposite season testing, the designer and owner shall be given timely notification before any readings or adjustments are made so that he may participate.

END OF SECTION 230593
PART 1 GENERAL

1.1 WORK INCLUDED

A. Contractor shall provide all necessary labor, materials, tools, and equipment to perform work required on the drawings and specified herein.

B. Certain equipment and/or systems to be factory insulated by manufacturer. Factory insulation materials to be as specified in applicable sections of the specifications.

C. All pipe fittings, valves, and strainers in insulated pipe systems to be insulated.

D. Thermal resistance "R" values used herein are expressed in units of "Hour, Degrees F., Sq. Ft./BTU per Inch of Thickness" on a flat surface at a mean temperature of 75 degrees F.

E. Note that where electric cable wrap is called for, insulation is to be applied over cable.

F. "Contractor's Option" referred to in Materials below indicates optional materials which may be used as equals.

1.2 DEFINITIONS

A. "Exposed" equipment, ducts, and piping are areas which will be visible without removing ceilings or opening access panels.

B. Outdoors is considered exposed to the weather.

C. Underground is buried, whereas in a trench below grade is considered concealed.

1.3 CERTIFICATION/QUALITY ASSURANCE

A. Products shall meet applicable national, state, and local building codes and be U.L. (or other recognized testing lab) listed for intended service.

B. All insulations, jackets, adhesives, coatings, sealers, and tapes shall have a flame spread rating of 25 or less and smoke development rating of 50 or less when tested in accordance with ASTM E-84, NFPA 225, U.L. 723, and further must meet the requirements of NFPA 90-A and applicable building, plumbing, and mechanical codes.

C. All insulation materials shall be delivered and stored in manufacturers’ containers and kept free from dirt, water, chemical, and mechanical damage. Under no circumstances
shall insulation applied to exterior ductwork be allowed to get wet prior to final material covering.

D. Insulation shall be applied in a workmanlike manner by experienced, qualified tradesmen.

E. Insulation shall not be applied until all pressure testing has been completed, inspected, and released for insulation application.

F. Surfaces shall be clean and dry.

G. Insulation joints shall be butted firmly together and all jackets and tapes shall be smoothly and securely installed.

H. Insulation for duct, pipe, and equipment for above grade exposed to weather outside building shall be certified as being self-extinguishing for 1” thickness in less than 53 seconds when tested in accordance with ASTM D-1692.

1.4 APPLICABLE CODES AND STANDARDS

A. ASTM E-84.

B. U.L. 723.

C. NFPA 90-A.


PART 2 PRODUCTS

2.1 MATERIALS FOR PIPE AND EQUIPMENT

A. Materials for Pipe and Equipment: Provide factory pre-molded or shop or site mitered segment type insulation for pipe, pipe fittings, and valves. Fitting insulation to be of same thickness and material as adjoining pipe insulation. All insulation and related materials such as tape and mastic to meet applicable building code requirements for fire and smoke development.

1. Flexible Tubular: Provide 25/50 rated, closed-cell, flexible tubular rubber type pipe insulation. Product to have continuous operational temperature limit of 200 degrees F. and a minimum "R" value of 3.7 per inch (K=0.27) at 75 degrees F mean temperature. Product to be Armstrong AP Armaflex or approved equal pipe insulation. Use flexible tubular for the following services:

a. Moisture condensate drains: 1” thick.

b. Horizontal runs of waste lines carrying cold condensate from air conditioning equipment: 1” thick.

c. Provide multiple layers as required to obtain minimum thickness.

d. All refrigerant lines for Variable Refrigerant Flow (VRF) systems: 1” thick.
2.2 MATERIALS FOR DUCTS

A. Blanket Type Duct Insulation: Provide minimum 3/4 pound per cubic foot density, flexible blanket fiberglass duct insulation with FSKL aluminum foil vapor barrier facing and 2" tab. Insulation shall have minimum ‘R’ value of 3.4 per inch (K=0.29) at 75 degrees F mean temperature. Product to be Manville "Microlite" or equivalent standard duct wrap by CertainTeed, Knauf, or Owens-Corning. Use blanket type duct insulation for the following:

1. Unlined heating and/or cooling supply and return air ductwork concealed from view: 2" thick.
2. Unlined outside air ductwork concealed from view: 2" thick.

2.3 MATERIALS FOR FITTINGS, VALVES, AND SPECIAL COVERINGS

A. Provide coverings and finishes for specific items hereinafter specified.

1. Use pre-molded insulation fabricated by the manufacturer of insulation material or shop or site mitered segment type insulation for: All pipe fittings, elbows, tees, valves, and couplings.
2. PVC fitting covers over blanket fiberglass are NOT acceptable.
3. Contractor’s option to provide factory pre-molded one-piece PVC insulated fitting covers, precut fiberglass insulation inserts, and necessary installation materials for all pipe fittings. Materials to be equal to Manville Zeston white, U.V. resistant, 25/50 rated, 20 mil thickness insulated PVC fitting covers and insulation inserts.
4. PVC fitting covers over blanket fiberglass are not acceptable for steam, gravity steam condensate, and steam boiler/deaerator piping services.
5. Insulation is not required for steam traps, steam, hot condensate, and hot water system strainers, relief valves, and steam pressure reducing valves. Insulate piping to within 3" of uninsulated items.

B. For heat exchangers, air separators, large pipes, etc., in systems operating over 60 degrees F., when exposed-to-view inside building or in equipment rooms, cover insulation with a smoothing coat of Keane Powerhouse cement, one layer of white colored glass mesh embedded and finished with Foster 46-50 mastic or Childers CP-10 / CP-11 mastic.

C. For pipe fittings, valves, strainers, air separators, and other irregular surfaces, in systems operating below 60 degrees F., when exposed to view inside building or in equipment rooms, cover insulation with white colored glass mesh embedded in white, fungus resistant vapor barrier coating Foster 30-80 AF. Coating shall meet ASTM D 5590 with 0 growth rating.

D. Fabricate and install readily removable insulation caps to facilitate service and maintenance accessibility to all strainers including suction diffusers in systems operating below 60 degrees F.

E. For any service when above grade exposed-to-the-weather outside building and exposed in equipment rooms, cover straight pipe insulation with 0.016" thick aluminum jacket equivalent to ITW or RPR and cover valves and fittings with .024" thick aluminum factory formed covers equivalent to Childers Ell-Jacs.
F. For any service when above grade exposed-to-the-weather outside building and exposed in equipment rooms, cover pipe insulation with 20 mil thick white, U.V. resistant, 25/50 rated PVC jacketing equivalent to Manville Zeston PVC jacketing and fitting covers. All joints to be made with solvent welding adhesive equivalent to Manville Perma-Weld to create a permanent chemical bond between the PVC members.

G. For any service, when below grade direct buried, cover straight pipe and fitting insulation with equivalent of Pittsburgh Corning "Pittwrap", Foster C.I. Wrap 50 or "Pittwrap SS11" jacketing. Valves in systems operating above 60 degrees F. and installed in valve boxes shall not be insulated; however, the valves shall be painted with a rust resistant product equivalent to Rustoleum.

H. For flexible tubular pipe and fitting insulation when exposed-to-view inside building or exposed to the weather, finish with two coats of paint, custom color blended to match surrounding surfaces.

I. For externally insulated sheet metal ducts when above grade exposed-to-the-weather outside building, cover duct insulation with Alumaguard 60 self-adhering weather and vapor barrier membrane by Polyguard or equal by FlexClad having proven ability to withstand a wide range of temperatures without cracking or crazing and that is highly resistant to damage by bumping and abrasion. Product color to be white unless otherwise noted. Apply in accordance with manufacturers’ published instructions.

J. When specifically approved by designer, when it is impossible to completely insulate pipe, fittings, or valves with specified insulation, Armstrong Armaflex insulation tape may be used to prevent condensate drip on small piping. Use of cork insulation tape is prohibited.

K. When exposed to view inside building or in equipment rooms, cover external duct insulation with a smoothing coat of Keane Powerhouse cement and one layer of white colored woven glass fabric embedded in white, fungus resistant lagging adhesive/coating, Foster 30-36 AF or Childers CP-137 AF. Coating shall meet ASTM D 5590 with 0 growth rating.

PART 3 EXECUTION

3.1 GENERAL

A. No insulation shall be cut where a hanger is located. If hangers have been installed by pipefitter tradesmen which violates this strict requirement, notify Designer immediately.

B. Piping and ductwork systems shall be tested and found free of all leaks prior to installation of insulation covering.

C. All surfaces shall be clean and dry when covering is applied. Covering to be dry when installed and during application of any finish, unless such finish specifically requires a wetted surface for application.
D. All adhesives, cements, and mastics shall be compatible with materials applied and shall not attack materials in either wet or dry state.

E. Install insulation using professional insulators who have adequate experience and ability.

F. Exposed-to-view insulation shall have a well-tailored appearance.

G. Stop all duct coverings, including jacket and insulation, at fire and smoke dampered penetrations of partitions. "Fan-Out" or extend jacketed insulation at least 2" beyond angle frames of dampers and secure insulation to partition. Maintain vapor barrier. Where insulated duct access door is not used, install covering over damper access panel so as to be readily removable and identifiable.

H. Treat insulated pipe and duct surfaces in equipment rooms and where exposed to normal view, so surfaces may be painted with water base latex paint. Use of mastics, adhesives, or jacketing which cause "bleeding" is prohibited.

I. Pipe hanger insulation shields and/or saddles shall be properly centered inside the pipe hanger to ensure that the piping insulation is not damaged.

J. Pipe hanger insulation shields shall be fabricated with a minimum metal gauge thickness in compliance with MSS SP-69.

3.2 INSTALLATION OF DUCT COVERING

A. Apply jacketed blanket type fiberglass covering to ducts pulled snug but not so tight as to compress corners more than 1/4". Use insulation having 2" tab, or cut insulation long enough to allow for "peel off" of insulation from jacket to effect a minimum overlap of 2". Secure 2" jacket laps using equivalent of Foster 85-75 or CP-82 adhesive and staple lap with flare type staples on 2" centers. Cover standing seams, stiffeners, and braces with same insulation blanket, using 2" jacket lap and staple lap as hereinbefore outlined. Cover and seal all staples with Foster 30/80 AF, fire resistant vapor barrier coating reinforced with glass cloth.

B. For duct 24" or wider, mechanically fasten insulation to duct bottom, using weld pins or nylon "stick-clip" base plates having self-locking coated metal or nylon discs. Locate fasteners on not over 12" centers laterally and longitudinally. Seal pins as above.

C. For ducts more than 20" deep, mechanically fasten insulation to duct sides, using one row of pins, plates, or discs located on not over 12" centers longitudinally and equidistant laterally between duct top and bottom. For ducts over 24" deep, apply fasteners as before only using minimum of two rows.

D. Apply jacketed board type fiberglass covering to ducts using weld pins or nylon "stick-clip" base plates having self-locking coated metal or nylon discs. Locate fasteners on not over 12" centers laterally and longitudinally. If insulation is grooved to fit around corners, in order to eliminate as many joints as possible, pin as required to hold
insulation tight to duct, especially on bottom of duct. Seal pins and joints with Foster 30-80 AF reinforced with glass mesh.

E. Cover all joints, rips, tears, punctures, disc heads, staples, or breaks in vapor barrier jacket with 4” wide woven glass fabric tape embedded in Foster 30-80 AF fire resistant vapor barrier coating. PRESSURE SENSITIVE TAPE NOT ALLOWED.

F. Prior to application of flexible sheet insulation, thoroughly clean all metal surfaces, making sure that all dirt, scale, loose paint, plaster, and oil have been removed and that surfaces are dry. If surface has been primed, test a 2 square foot section using adhesive equivalent to Armstrong 520, Foster 85-75 or Childers CP-82 in order to determine whether solvent in adhesive will loosen or lift the primer. If primer is loosened, then remove it. When testing proves acceptable, adhere insulation with smooth side out, using thin but adequate coating of same adhesive. Follow manufacturers’ instructions. Coat all butt edges of each sheet. Stagger all joints. Insulate all standing seams or flanges with same thickness of insulating material as that used on main surface. Seal all butt joints, miter joints, and torn or damaged insulation with adhesive.

G. Ductwork manual volume damper (MVD) handles, airflow station pressure ports, access door handles, duct-mounted instrumentation, etc., shall be left exposed and/or accessible above the insulation vapor barrier.

3.3 INSTALLATION OF PIPE AND EQUIPMENT COVERING

A. Where fiberglass or flexible tubular insulation is used on piping sized 2” and larger, insert a section of foamglass insulation at hanger or support points between pipe and metal shield for full length of shield to prevent crushing of insulation. Insulation thickness to be same as adjoining insulation. Where insulation passes through pipe hangers and across trapeze supports, 12” long metal saddles shall be used. On cold pipe, vapor barrier should be carried through the hanger and sealed.

B. Apply flexible tubular insulation to pipe and fittings using the slip-on method with all joints tightly fitted and sealed with Armstrong 520, Foster 85-75, Childers CP-82 adhesive or approved equal. Seal butt joints, miter joints and torn or damaged insulation with adhesive.

C. Apply PVC insulated fitting covers and precut insulation inserts as follows:
1. Installation for hot systems:
   a. Place the precut fiberglass insert around the fitting, positioning the points of the insert on the inside radius of the elbow.
   b. Butt the ends of the fiberglass insert against the ends of the pipe covering. Tuck and fold the insulation so that it covers all bare surfaces. Keep the fiberglass fluffed up to the thickness of the adjacent pipe insulation to assure maximum thermal efficiency.
   c. Insert two stainless steel serrated tacks approximately 1/4” from one of the lap edges of the fitting cover. Then snap the cover in place over the fiberglass insulation.
d. After the fitting cover is in position, push the tacks into the overlapping throat seam. Apply color-matched, pressure-sensitive tape to the butt joints.

2. Installation for cold systems:
   a. Position, tuck, and fold the fiberglass insulation insert as described above in steps (a) and (b) for hot systems.
   b. Apply a vapor barrier mastic around the edges of the adjoining pipe insulation. Apply the mastic along the inside of the fitting cover throat overlap seam.
   c. Place the fitting cover over the insulation, lapping the mastic-covered edge over the other side of the throat seam.
   d. Apply color-matched, pressure-sensitive tape over the circumferential joints. The tape should extend over the adjacent pipe insulation and overlap itself by at least 2" on the downward side of the lap.

END OF SECTION 230710
SECTION 230923
DIRECT DIGITAL CONTROL/BUILDING AUTOMATION SYSTEM (DDC/BAS)

PART 1 GENERAL

1.1 DESCRIPTION

A. Direct Digital Control/Building Automation Systems (DDC/BAS) shall be Trane or CSI.

B. All new points are to be mapped back to and integrated with existing Trane or CSI front end. Provide software upgrade to accept new controllers and graphics updates if required to integrate project.

C. The work specified under this section of the specifications includes furnishing, installing, programming, and placing into operation the DDC/BAS systems. Systems shall be furnished, installed, and warranted by the manufacturer.

D. The DDC/BAS systems shall be furnished and installed under this section of the specifications and shall consist of microprocessor based digital system controllers. The systems shall have the ability for extension to other buildings by web addressable server. The systems shall be complete in every respect, including all auxiliary and accessory items as required, and shall be thoroughly coordinated so as to provide a compatible and completely workable system.

E. Provide a complete control system including electrical interlocks, wiring, conduit, relays, switches, control transformers, and other devices as required to accomplish automatic control of the mechanical systems. Refer to drawings for details.

F. All systems shall be guaranteed against defects of any nature and to operate properly for a period of not less than 12 months after final acceptance of the job by the Owner. During this period, the BAS manufacturer shall service and adjust the systems as required for proper operation, replacing components as required.

G. The contractor shall work in close cooperation with the TAB agency in calibrating all airflow and water flow stations and all duct and pipe mounted differential pressure sensor/transmitters.

H. Submit complete shop drawings, equipment and component brochures, list of control valve CV and pressure drops, list of control dampers, written sequences of operations, diagrams indicating panels, gauges, components, spring ranges, and setpoints, and complete composite wiring diagrams indicating all equipment interlocks for entire control system.
PART 2 PRODUCTS

2.1 GENERAL PRODUCT DESCRIPTION

A. The building automation system shall consist of the following:
   1. Stand-alone DDC panels.
   2. Stand-alone application specific controllers (ASCs).
   3. Portable laptop PC operator terminal.
   4. DDC panel-mounted operator terminal.
   5. Web addressable server

B. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, stand-alone DDC panels, and operator devices.

C. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

D. Stand-alone DDC panels shall be able to access any data from or send control commands and alarm reports directly to any other DDC panel or combination of panels on the network without dependence upon a central processing device. Stand-alone DDC panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.

2.2 NETWORKING/COMMUNICATIONS

A. The design of the BAS shall network operator workstations and stand-alone DDC panels.

B. Local Area Network:
   1. Workstation/DDC Panel Support: Operator workstations and DDC panels shall directly reside on a local area network such that communications may be executed directly between controllers, directly between workstations, and between controllers and workstations on a peer-to-peer basis.
   2. Dynamic Data Access: All operator devices shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network.
   3. General Network Design: Network design shall include the following provisions:
      a. High speed data transfer rates. The minimum transfer rate shall be 100 Mb (Mb/s).
      b. Commonly available, multiple source, networking components and protocols shall be used to allow the BAS to coexist with other networking applications. MAP, ETHERNET, IBM Token Ring and ARCNET are acceptable technologies.
c. Use of an industry standard IEEE protocol.
d. Synchronization of the realtime clocks in all DDC panels shall be provided.
e. Permit at least four simultaneous users to access the system over the LAN, based on password level. Users shall have access to monitor parameters, change set points, set up trends, or start/stop controlled equipment. A remote user shall have this capability without having the system data base loaded on his/her remote computer.
f. Paging/Email feature shall be provided with capability to telephone/email selected facility maintenance personnel to notify them of critical BAS alarms.

4. Connection to Facility’s LAN: The BAS shall be connected to the facility’s Ethernet LAN to the extent possible to avoid duplication of LAN wiring. Coordinate connection with owner.

2.3 STAND-ALONE DDC PANELS

A. General: Stand-alone DDC panels shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors. Each stand-alone DDC panel shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules.

B. Memory: Each DDC panel shall have sufficient memory to support its own operating system and databases.

C. Point Types: Each DDC panel shall support the following types of point inputs and outputs:
   1. Digital Inputs for status/alarm contacts
   2. Digital Outputs for on/off equipment control
   3. Analog Inputs for temperature, pressure, humidity, flow, and position measurements
   4. Analog Outputs for valve and damper position control, and capacity control of primary equipment
   5. Pulse Inputs for pulsed contact monitoring

D. Expandability: The system shall be modular in nature, and shall permit easy expansion through the addition of software applications, workstation hardware, field controllers, sensors, and actuators.

E. Serial Communication Ports: Stand-alone DDC panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices such as industry standard printers, laptop workstations, PC workstations, and panel mounted or portable DDC panel operator’s terminals. Stand-alone DDC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or network terminals.

F. Hardware Override Switches: The operator shall have the ability to manually override automatic or centrally executed commands at the DDC panel via local, point discrete, on-board hand/off/auto operator override switches for binary control points and gradual
switches for analog control type points. These override switches shall be operable whether the panel is powered or not.

G. Hardware Override Monitoring: DDC panels shall monitor the status or position of all overrides and inform the operator that automatic control has been inhibited.

H. Local Status Indicator Lamps: The DDC panel shall provide local status indication for each binary input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.

I. Integrated On-Line Diagnostics: Each DDC panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all subsidiary equipment.

J. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standard 587-1980. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

K. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all stand-alone DDC panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention.

L. Provide a battery backup (UPS) system to support DDC panel functions for a minimum of 15 minutes upon loss of power. The UPS system shall be provided regardless of connection to facility emergency power system.

2.4 SYSTEM SOFTWARE FEATURES

A. General:
1. All necessary software to form a complete operating system as described in this specification and on drawings shall be provided.
2. The software programs shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher level computer for execution.

B. Control Software Description:
1. Pre-Tested Control Algorithms:
   a. Two Position Control
   b. Proportional Control
   c. Proportional plus Integral Control
   d. Proportional, Integral, plus Derivative Control
   e. Automatic Control Loop Tuning
2. Equipment Cycling Protection.
3. Heavy Equipment Time Delays.
C. Energy Management Applications: DDC panel shall have the ability to perform any or all of the following energy management routines:
   1. Time of Day Scheduling
   2. Calendar Based Scheduling
   3. Holiday Scheduling
   4. Temporary Schedule Overrides
   5. Optimal Start/Stop
   6. Night Setback/Setup Control
   7. Economizer
   8. Peak Demand Limiting
   9. Temperature Reset

D. Custom Process Programming Capability: DDC panels shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

E. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to noncritical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC workstation or local I/O device, or communications with other panels on the network.

F. Historical Data and Trend Analysis: A variety of historical data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways:
   1. Continuous Point Histories.
   2. Control Loop Performance Trends.
   3. Extended Sample Period Trends.
   4. Data Storage and Archiving.

G. Runtime Totalization: Stand-alone DDC panels shall automatically accumulate and store runtime hours for binary input and output points.

H. Analog/Pulse Totalization: Stand-alone DDC panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

I. Event Totalization: Stand-alone DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off.

2.5 APPLICATION SPECIFIC CONTROLLERS - HVAC APPLICATIONS

A. Each stand-alone DDC controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASCs).
B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.

C. Each ASC shall have sufficient memory to support its own operating system and data bases.

D. The operator interface to any ASC point data or programs shall be through any network-resident PC workstation or portable operator's terminal connected to any DDC panel in the network.

E. Application specific controllers shall directly support the temporary use of a portable service terminal.

F. Powerfail Protection: All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller.

G. Battery Backup (UPS): UPS shall be provided to support ASC functions for a minimum of 15 minutes upon loss of power. The UPS system shall be provided regardless of connection to facility emergency power system.

H. The modes of operation supported by each ASC shall minimally include, but not be limited to, the following:
   1. Daily/Weekly Schedules
   2. Occupancy Mode
   3. Economy Mode
   4. Temporary override Mode

I. Continuous Zone Temperature Histories: Each ASC shall automatically and continuously maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.

J. Alarm Management: Each ASC shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

K. Application Descriptions:
   1. Unitary Controllers:
      a. Unitary controllers shall support, but not be limited to, the following types of systems to address specific applications indicated on the drawings:
         1) Unit Ventilators (ASHRAE Cycle I, II, III, or W)
         2) Heat Pumps (Air-to-Air, Water-to-Air)
         3) Packaged Rooftops
         4) Fan Coils (Two-Pipe, Four-Pipe)
b. Unitary controllers shall support the following types of point inputs and outputs:
   1) Economizer Switchover Inputs
   2) Drybulb
   3) Outdoor Air Enthalpy
   4) Differential Temperature
   5) Differential Enthalpy
   6) Binary Input from a separate controller
   7) Economizer Outputs
   8) Integrated Analog with minimum position
   9) Binary output to enable self-contained economizer actuator
   10) Heating and Cooling Outputs
   11) 1 to 3 Stages
   12) Analog Output with two-pipe logic
   13) Reversing valve logic for Heat Pumps
   14) Fan Output
   15) On/Off Logic Control

2. AHU Controllers:
   a. AHU controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally stand-alone fashion.
   b. AHU controllers shall have a library of control routines and program logic to perform the sequence of operation.

2.6 OPERATOR INTERFACE

A. Command Entry/Menu Selection Process: Operator workstation interface software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software.

B. The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

C. Graphical and Text-Based Displays: At the option of the user, operator workstations shall provide consistent graphical or text-based displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all workstations.

D. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password.

E. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:
   1. Start-up or shutdown selected equipment.
   2. Adjust setpoints.
3. Add/Modify/Delete time programming.
4. Enable/Disable process execution.
5. Lock/Unlock alarm reporting for each point.
6. Enable/Disable Totalization for each point.
7. Enable/Disable Trending for each point.
8. Override PID Loop setpoints.
9. Enter temporary override schedules.
10. Define Holiday Schedules.
11. Change time/date.
12. Enter/Modify analog alarm limits.
13. Enter/Modify analog warning limits.
15. Enable/Disable Demand Limiting for each meter.

F. Logs and Summaries: Reports shall be generated automatically or manually, and directed to either CRT displays, printers, or disk files. Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the building automation system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.

G. Dynamic Color Graphic Displays: Color graphic floor plan displays, and system schematics for each piece of mechanical equipment shall be provided to optimize system performance analysis and speed alarm recognition.

H. Graphics Generation Package: Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays.

I. System Configuration and Definition: All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.
   1. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently add/delete/modify all functions.
   2. Programming Description: Definition of operator device characteristics, DDC panels, individual points, applications, and control sequences shall be performed through fill-in-the-blank templates and graphical programming approach.
   3. System Definition/Control Sequence Documentation: All portions of system definition shall be self-documenting to provide hardcopy printouts of all configuration and application data. Control process and DDC control loop documentation shall be provided in logical, graphical flow diagram format to allow control sequences to be easily interpreted and modified at any time in the future.
2.7 PORTABLE LAPTOP PC OPERATOR TERMINAL

A. Furnish one Portable Laptop PC Operator's Terminal and software to be used for communication with any controller. The terminal shall be a Windows Vista Business edition based laptop personal computer that uses controller interface software to communicate with the controllers. Manufacturer shall be Dell, Inc. or approved equal.

B. When plugged into any controller on the BAS network, the portable terminal shall have the same functionality as a stationary terminal with full editing, programming, display, and command functions. The terminal shall allow access to the entire network.

C. The terminal shall have minimum 3.0 GHZ Intel i7 processor, 4.0 GB RAM internal memory, built-in 250 GB hard drive and 48X CDRW/DVD Combo drive. In addition, the terminal shall have two USB ports Nic-Ethernet.

2.8 STAND-ALONE DDC PANEL-MOUNTED OPERATOR'S TERMINAL

A. Each DDC panel (except VAV terminal unit controllers) shall include a local panel-mounted operator's terminal for local command entry, instantaneous and historical data display, setpoint adjustment and program additions and modifications.

1. The DDC panel operator terminal shall provide access to all real or calculated points in the controller to which it is connected or any other controller in the network.

2. Operator access at all DDC panel operator terminals shall be identical to each other, as well as identical to the PC operator workstations. Any password changes shall automatically be downloaded to all controllers on the network.

3. The DDC panel operator terminal shall provide English language prompting to eliminate the need for the user to remember command formats or point names.

4. A multi-function touchpad shall be provided for point and command selection, as well as parameter entry.


6. Identification for all real or calculated points shall be consistent for all network devices. Use English language names to access points at the DDC panel operator's terminal.

7. In addition to instantaneous summaries, the DDC panel operator's terminal shall allow a user to view a point history file for system points.

2.9 ELECTRONIC, ELECTRIC AND PNEUMATIC CONTROL COMPONENTS

A. All sensors, pressure transmitters, transducers, etc., shall be selected such that the pressure range midpoint shall coincide with the anticipated normal operating pressure.

B. Electric Thermostats: Thermostats to be manufacturer's best commercial grade thermostat with adjustable setpoint, dials calibrated in degrees F, and digital temperature indication. Select thermostats with suitable range for service intended. Temperature measurement accuracy shall be +/- 0.5 degrees F. Thermostats located in public areas such as corridors or elsewhere as indicated on drawings shall be provided with programming lockout to prevent unauthorized adjustment. Thermostats...
located where subject to physical damage and/or where identified on drawings shall be provided with tamper resistant cover. Warmer – Cooler setpoint adjustment will not be acceptable.

C. Electronic Sensors/Transmitters: Sensors/transmitters to be 1000 Ohm platinum RTD type with high resistance change vs. temperature or humidity change, accurate to +/- 0.3 degrees F for temperature and +/- 2.0% for humidity at applicable range, and provide 4 to 20 MA or 0 to 5 VDC output signal. Sensors/transmitters to be suitable for room, duct, or well mounting as required by application. Room type to have built-in setpoint potentiometer and digital room temperature or humidity indication. Select for temperature/humidity range of application. Provide appropriate mounting plate and hardware. Temperature sensors used as a part of Energy (BTU) Measurement System shall meet the applicable requirements of that section. Sensors shall have setpoint adjustment through BAS only. Sensors located where subject to physical damage and/or where identified on drawings shall be provided with protective cover. Provide these devices where identified on the contract documents or if not shown on design documents provide at all locations listed within this section. Humidity sensors are to be stand-alone sensors and at a minimum provided within each Operating Room, C-Section, Post Anesthesia Care Unit, Critical Care Patient Room, Intensive Care Patient Room, Wound Intensive Care (Burn Unit) Newborn Intensive Care Treatment Room, Trauma Room, Laser Eye Room, Newborn Nursery, Procedure Room, Decontam and Clean work within Central Sterile Department if not already shown on the contract documents.

D. Smoke Detectors: Install duct-mounted smoke detectors at locations indicated on drawings and in accordance with published smoke detector installation requirements. Smoke detectors to be furnished to Division 23 by Division 26.

E. Freezestats (Low Limit Binary Type): Provide single, custom length Freon-filled capillary tube type with sensing element actuated by temperature on any one foot portion. Sensor shall be a single element with length of one linear foot for every one square foot of coil face area. Freezestats to be UL approved, manual reset type.

F. Averaging Temperature Sensors (Mixed Air, Preheat, Etc.): Provide single, custom length Freon-filled capillary tube type sensing element. Accuracy shall be +/- 0.3 degrees F. Sensor shall be single element with length of one linear foot for every one square foot of coil face area.

G. Control Panels: Control panels to be constructed of unitized steel or aluminum cabinets. Provide cabinets with hinged, locking door opening to the front. Multiple panels mounted side-by-side to be hinged to the left or on opposite sides to open in the middle. Start-stop switches, hand-off-automatic switches, pilot lights, and temperature indicating devices to be flush-mounted in panel door. All other devices to be internally mounted within panel. Local panels exposed to weather to be weatherproof construction. Panel locations to be approved by Designer and be accessible for operation and maintenance. All devices specified to be mounted on control panel that require electrical connections to be prewired to a dual, numbered terminal strip located inside panel. Pneumatic piping inside panel may be poly properly supported in laced bundles or in panduit trays. All lines in panel shall have number I.D. bands. Gauges
shall be installed on all pneumatic lines entering or leaving the panel. All devices inside the panel or mounted on panel face shall have an engraved laminated plastic nameplate. Wiring within panel to conform to National Electrical Code, and shall be neatly bundled and enclosed in panduit trough.

H. Automatic Control Dampers: Ultra low-leak automatic control dampers to be Arrow Pin Lock opposed-blade dampers for modulating control and parallel blades for 2-position control or approved equal. Frames and blades to be minimum 16 gauge extruded aluminum or galvanized steel construction with 4" to 6" deep frame and 8" maximum width blades. Pivot rods to be 1/2" diameter, extruded aluminum or plated steel. Bearings to be corrosion resistant. Install blade linkage hardware in angle or channel frame section out of airstream. All hardware to be corrosion resistant. Seals to be replaceable extruded vinyl or silicone rubber blade seals and flexible metal compression type jamb seals. Dampers to have maximum 4 cfm per square foot leakage at 1" water gauge static pressure and 8 cfm per square foot leakage at 4" water gauge static pressure, verified by independent testing laboratory.

I. Electronic Actuators: Actuators shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. End switches to deactivate the actuator at the end of rotation or magnetic clutch is not acceptable. For power-failure/safety applications, a mechanical, spring return mechanism shall be used. Non-mechanical forms of fail-safe are not acceptable. All spring return actuators shall be capable of both clockwise or counterclockwise spring return operation by changing mounting orientation. Proportional actuators shall accept a 2 to 10 VDC or 4 to 20 mA and provide a 2 to 10 VDC position feedback signal. 24 VAC/DC actuators shall not require more than 15 VA for AC or 8 watts for DC applications. All non-spring return actuators shall have an external manual gear release to aid in installation and allow manual positioning when the actuator is not powered. All actuators shall have an external direction of rotation switch to aid in installation and provide proper control response. Actuators shall be provided with a factory-mounted 3-foot electrical cable and conduit fitting to provide easy hook-up to an electrical junction box. Provide cover mounted control transformer for 120-VAC power supply. The actuators shall be U.L. listed.

J. Static Pressure Devices: Static pressure measuring stations with +/- 2% accuracy equal to Paragon Controls PE-5000 shall be provided. Industrial quality, electronic solid state, 1/2 percent accuracy static pressure transmitters equal to Paragon Controls Model DPT-4001 shall be provided. Transmitter span shall be matched to application.

K. Transformers: Provide all 24-volt control transformers necessary to convert 120-volt line voltage power to control voltage at control devices.

L. Relays, Hand-Off-Auto Switches, Pilot Lights: Provide all relays, hand-off-auto switches, and pilot lights necessary to accomplish automatic control of the mechanical systems. See electrical drawings for starters provided integral with hand-off-autos, pilot lights, and auxiliary contacts.

M. Pressure Switches: Pressure switches shall have contact action and pole configuration as required by application, U.L. listing, and adjustable setpoint.
N. Current Sensing Relays:
   1. Acceptable Manufacturer: Hawkeye Model 908 or approved equivalent.
   2. Current sensor shall be induce powered from the monitored load and shall have an adjustable operating range from 2.5 - 135 A. Visual indicators (LEDs) shall indicate output status and sensor power. Adjustable trip setpoint to +/- 1%. Current sensor output shall be N.O., solid state, 0.1A @ 30 VAC/DC.

PART 3 EXECUTION

3.1 INSTALLATION

A. Components:
   1. Provide sensors, transmitters, controllers, actuators, valves, dampers, and related items, necessary to accomplish control sequence shown on drawings. Install all such devices except as noted herein to the contrary.
   2. Deliver control valves to the job site to be installed by Contractor.
   3. Deliver automatic dampers to the job site to be installed by Contractor.
   4. Contractor to install flow switches, immersion wells, pressure tapping, and all associated shut-off cocks required for control systems.
   5. The control equipment and connecting piping shall be installed in a neat and workmanlike manner by trained mechanics in the direct employ of the control manufacturer.
   6. All exposed tubing and conduit shall be run parallel to or at right angles to the building structure, and shall be concealed in all finished spaces. Tubing and conduit may be run exposed in mechanical rooms or areas where other piping is exposed.
   7. Prepare coordinated composite wiring diagram showing all interlock wiring associated with starters, control panels, and controls.
   8. Drawings and Layouts: The controls contractor shall provide to the mechanical contractor complete schematic drawings for the entire control system for submittal to the Designer for approval before work shall begin. Brochures describing each item of control equipment or component shall be included.
   9. Provide sequence of operation written so that building engineer can read and understand control scheme.
   10. As-built drawings to be framed under plexiglass and placed in each respective equipment room area.

B. Electrical:
   1. Contractor shall furnish and install low-voltage control wiring, including conduit, conductors, and terminations for same. Division 23 shall also furnish and install control components associated with the low-voltage control systems and shall wire and connect components in accordance with approved wiring diagrams.
   2. Contractor shall furnish and install power wiring including conduit, conductors, and terminations to motors, safety switches, starters, relays, valve and damper actuators, and other components requiring power as indicated on the electrical drawings, by the specifications, and in accordance with approved wiring
diagrams. Contractor shall also furnish and install starters as scheduled on the electrical drawings.

3. Contractor to furnish and install all local area network wiring, including conduit, conductors, and terminations for same. The local area network (LAN) shall be configurable as either a bus or a star, or a combination of the two. The LAN shall use twisted pair, coax, or fiber optic cable, or any combination of the three to meet noise immunity and/or distance requirements. The network design shall provide a high speed data transfer rate for alarm and report generation of no less than 100 Mb (Mb/s).

4. Contractor to furnish all input and output control wiring, including conduit, conductors, and terminations for same. All input and output control wiring shall be #18 twisted and shielded cable. No input or output point shall be more than 250 feet from its respective panel. All shields to be grounded at the control panel. All shields at the sensors or transducers to be folded back and taped. All cable splices shall have joints soldered and taped including the shield. No mechanical connections will be acceptable. All connections within the panels must be made with connectors of appropriate size and design for the terminals being applied. All cables must be labeled and identified on corresponding termination drawings. A copy of the termination drawing shall be adequately protected and left in its respective panel.

5. Install all control wiring associated with DDC/BAS in minimum 1/2" size EMT. Provide all associated couplings, connectors, and fittings. No electrical wiring and polyethylene tubing may occupy the same conduit. Separate carriers are required.

6. All wiring shall be in accordance with local regulations and the National Electrical Code.

C. Room Devices:
   1. Room devices shall be mounted so that the top of the device is 48" above the floor and aligned with the top of the light switch plates and 8" from the light switch if shown on the drawings adjacent to the light switch.
   2. Room device locations shall be coordinated with door swings, light switches, and other wall-mounted items.

3.2 QUALITY CONTROL

A. Control system to be set up and checked out by factory-trained competent technician skilled in the setting and adjustment of temperature controls used in this project. This mechanic to be experienced in type systems associated with this control system.

B. At time of final observation, Control Contractor to demonstrate the entire sequence of operation for the systems to the Engineer. At this time, Engineer to observe function of entire control system, observe temperature control operations, damper positions, necessary to assure that temperature control system is operating as intended by mechanical design.

C. Final acceptance of system not to occur until sequence of operation check has taken place and certified by Engineer's representative.
D. The Control Tradesman to be responsible for returning to job during the opposite season to verify operation of control system. Engineer to be given notice of this return and to accompany Control Tradesman to observe the sequence of operation.

3.3 INSTRUCTION AND ADJUSTMENT

A. On completion of the job, the controls contractor shall have completely adjusted the entire control system. He shall arrange to instruct the Owner's representative on operation of the control system and supply him with three (3) copies of the control operating and instruction manuals.

B. The Controls Contractor shall obtain from the Owner's representative a signed receipt that he has received the instruction manuals and complete instruction on the operation of the system.

C. Contractor Adjustment: At the completion of the job, the controls contractor must submit to the Architect a letter stating that he has made final calibrations and adjustments to the system and that the Owner's operating personnel have been instructed in its use.

3.4 WARRANTY SERVICE

A. Warranty servicing shall be for a period not less than 12 months after final acceptance of the job by the owner and include the following provisions:
   1. Emergency maintenance service on regular working hour basis during warranty.
   2. Replacing defective parts and components as required.
   3. Servicing by factory trained and employed service representatives of system manufacturer.
   4. Maintaining of system programming.

END OF SECTION 230923
OAKLAND ELEMENTARY SCHOOL
HYDRONIC PIPING
12 CLASSROOM ADDITION
SECTION 232113

SECTION 232113
HYDRONIC PIPING

PART 1 GENERAL

1.1 WORK INCLUDED

A. Submit pipe, valves, and fittings and have approved before starting installation. Pipe, valves, and fittings to be new, manufactured domestically, and marked clearly with manufacturers' name, weight, and classification or working pressure.

B. Piping to run approximately as shown on drawings or as structural and architectural conditions permit.

C. Provide seismic analysis and bracing of all piping systems in accordance with Section 230547 - Seismic Restraint of Mechanical Equipment and Suspended Utilities.

PART 2 PRODUCTS

2.1 STEEL PIPES

A. Butt welded, electric resistance welded, or seamless black steel pipe, ANSI B 36.10, ASTM A-53, Grade "B" or "A", Schedule 40 for piping 10" and smaller for the following services:
1. Chilled water supply and return piping 2-1/2" and larger.
2. Hydronic heat pump supply and return piping 2-1/2" and larger.
3. Condenser water supply and return piping.
4. Heating hot water supply and return piping 2-1/2" and larger.
5. Combination heating/cooling water supply and return piping 2-1/2" and larger.
6. Fuel oil piping.
7. Compressed air piping.
8. Mill wrap all uninsulated underground steel pipe with Republic X-Tru-Coat or equal.

B. Standard-weight galvanized steel pipe: Air-conditioning unit moisture condensate drain piping.

2.2 STEEL PIPE FITTINGS

A. Flanges, fittings, unions and other products recognized as regularly available products to be marked in accordance with MSS SP-25. Markings on products of small size or shape may be omitted in the sequence allowed by MSS SP-25, except manufacturers' name or trademark.
B. Fittings 2-1/2” and larger to be standard weight, carbon steel, buttwelding fittings conforming to ASTM A-234 and ANSI B16.9.

C. Fittings to be factory-forged in USA and shall not have been machined, remarked, painted, or otherwise produced domestically from non-domestic forgings.

D. Branch connections from mains or headers 2-1/2” or larger to be welded tees or welding outlets. Outlets to be equal to Weldolets or Threadolets manufactured by Bonney Forge. Forged outlets to be used only if branch line is at least one pipe size smaller than main or header. Stub-in welded piping is not acceptable. T-drill branch tee connections shall not be allowed for HVAC piping.

E. Fittings 2” and smaller to be threaded, Class 150, standard, malleable iron fittings, conforming to ANSI B16.3 and ASTM A-197.

F. Contractor's option to use welded steel for pipe sizes 1-1/2” and 2” in size.

G. Fittings for galvanized steel pipe to be same as above except have galvanized coating. Fittings for waste, vent, and drainage piping to be drainage pattern type.

H. Flanges to be 150 lb. carbon steel conforming to ASTM A-105, ASTM A-181, and ANSI B16.5.

I. Flanges to be factory forged in U.S.A.

J. Unions to be Class 150 malleable iron with bronze-to-iron ground joint conforming to ANSI B16.39, ANSI B1.20.1, and ASTM A-197.

K. Bolting materials to be semi-finished carbon steel bolts and hex nuts conforming to ASTM A-307. Threads and dimensions to be in accordance with ANSI B1.1 and B18.2.

L. Thread lubricant to be Crane "Formular 425" or equal. Approved Teflon tape may be used at Contractor's option.

M. Gaskets to be 1/8" thick "Cranite", "Sepco" or equal.

2.3 PVC PIPE

A. Schedule 40 PVC pipe, ASTM D-1785 Type 1, Grade 1, 200-psi test: A/C unit condensate drains.

B. Fittings to match piping system. Fittings to have manufacturer's trademark permanently identified in accordance with MSS-SP-25. Supplier to include with submittal data certification that fittings and flanges have met requirements.

C. Joints for piping to be made with tetrahydrofuran solvent cement. Joints to be in accordance with manufacturer's recommendations.
D. Pipe, fittings, and cement to all be supplied by single manufacturer for entire project.

2.4 HANGERS

A. Insulated steel piping 1/2" thru 24", galvanized piping 1/2" thru 24", copper piping 1/2" O.D. thru 4" O.D., PVC pipe, with no longitudinal movement to be Grinnell Figure 260, MSS SP-69 Type 1, adjustable clevis hanger with Figure 167, MSS SP-69 TYPE 40, galvanized steel insulation protection shield sized for maximum 10' span on 4 psi compressive strength insulation.

B. Non-insulated copper tubing and PVC pipe 1/2" O.D. thru 4" O.D. with no longitudinal movement to be Grinnell Figure CT-99C, MSS SP-69 TYPE 9, plastic coated adjustable tubing ring hanger.

C. Insulated steel piping 1" thru 30" with longitudinal movement to be Grinnell Figure 171, MSS SP-69 TYPE 41, pipe roll complete with Figure 160, MSS SP-69 TYPE 39A or 39B, pipe insulation protection saddle sized for proper pipe size and insulation thickness.

D. Insulated copper piping 1/2" O.D. thru 2-1/8" O.D. with longitudinal movement to be Grinnell Figure 171, MSS SP-69 TYPE 41, pipe roll complete with Figure 167, MSS SP-69 TYPE 40, galvanized steel insulation protection shield sized for maximum 10' span on 4 psi compressive strength insulation.

E. Support copper pipe risers and PVC pipe risers by Grinnell Figure CT-121C, MSS SP-69 TYPE 8, plastic coated riser clamps at floor penetrations.

F. Support steel pipe risers by Grinnell Figure 261, MSS SP-69 TYPE 8, riser clamps at floor slab penetrations.

G. Support three or more parallel lines by trapeze hangers utilizing Unistrut channel or equal in bottom mounting arrangement with rod hanging support.

H. Adequately size hangers on insulated piping for insulation to pass continuously through hangers. Insulated piping to be supported outside insulation covering.

I. Provide concrete inserts, Grinnell Figure 282, MSS SP-69 TYPE 18, universal concrete insert, for attaching hangers to building structure. Inserts to be adequately sized and correctly positioned to support piping, valves, etc., when full of water and system is in operation.

J. Provide C-clamps with locknut, Grinnell Figure 86, MSS SP-69 TYPE 23, where piping is to be hung from steel beams. Welding hanger rods to steel members is not permitted. Provide malleable beam clamps, Grinnell Figure 218, MSS SP-69 TYPE 30, with extension piece, Grinnell Figure 157, where piping is hung from bar joist.

K. Attention is called to pipe spring isolation specified to be furnished by this Contractor.
L. Support all piping by heavy steel, adjustable hangers, or brackets suitably fastened to structural portion of building. Place hangers in accordance with following tables:

<table>
<thead>
<tr>
<th>STEEL PIPE SUPPORTS</th>
<th>SIZE (IN.)</th>
<th>DISTANCE BETWEEN SUPPORTS (FT.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4 - 1-1/4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>1-1/2 - 2-1/2</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>4 - 6</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>8 - 12</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>14 - 24</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COPPER TUBING SUPPORTS</th>
<th>SIZE (IN.)</th>
<th>DISTANCE BETWEEN SUPPORTS (FT.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7/8 - 1-1/8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>1-3/8 - 2-1/8</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2-5/8 - 5-1/8</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>6-1/8 - 8-1/8</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

| PVC AND CAST IRON SUPPORTS | SUPPORT each fitting, at intervals of not more than 5 feet, and at least at each joint. |

M. Perforated metal, strap iron, or band iron hangers are not permitted. Offsets in hangers are not allowed. Pipe risers to be supported at regular intervals in pipe shafts within the limits of good practice.

N. See Insulation Section for requirements at pipe hangers.

O. Support horizontal piping across roof in accordance with Section 230549.

2.5 CONTRACTOR OPTION

A. At Contractor's option steel pipe may be used in lieu of copper tubing for the following services:
   1. Chilled water supply and return piping 1-1/2" and larger.
   2. Hydronic heat pump supply and return piping 1-1/2" and larger.
   3. Heating hot water supply and return piping 1-1/2" and larger.
   4. Combination heating/cooling water supply and return piping 1-1/2" and larger.
   5. Where steel pipe is substituted for copper tubing in accordance with the above, valve types, hangers, fittings, and accessories shall be coordinated accordingly. Steel piping type and specifications to be as specified under "Steel Pipe" for like services.
PART 3 EXECUTION

3.1 INSTALLATION

A. Install piping not to interfere with opening of doors or other moving parts. Do not install piping near or directly over any portion of electrical equipment.

B. Provide chromium-plated escutcheon plates for exposed uninsulated pipes projecting through floors or walls in finished spaces. Mechanical rooms and janitor closets are not considered "finished" spaces.

C. Hang piping so equipment, flanges, and connections do not bear weight of piping.

D. Adequately support vertical lines at their bases or by a suitable hanger placed in horizontal line near riser or by a base fitting set on pedestal.

E. Pipes not to be hung or supported by pumps. No torque to be applied to pumps by connecting pipes. After final pipe adjustments and initial operation of the pumps, this Contractor to recheck alignment of pumps and realign as required.

F. Run piping in straight lines; riser lines to be plumb with such offsets only as indicated or necessary. No sagging of lines permitted.

G. Unless otherwise shown on drawings, lines to be installed to drain to sumps or sewer.

H. Ream pipe after cutting to full bore. Remove foreign matter from inside of pipe before installing. Keep installed piping free from dirt and scale and protect open ends from foreign matter. Use temporary plugs or other approved methods of open end closure.

I. Threads to be right-hand, pipe standard, clean cut, full depth, and tapered. Joints to be made tight without caulking. Approved pipe joint lubricant to be used, applied in thin layer to the male thread only.

J. Install copper fittings with suitable flux. Type K copper pipe to be joined by means of suitable flux and silver or phos-copper.

K. Piping to have sufficient number of flanges or unions for convenient installation and removal of piping and equipment.

L. Remake or replace defective, leaking, or otherwise unsatisfactory joints or material. Peening, caulking, or doping of piping is not permitted.

M. Install piping to prevent stresses and strains to piping and hangers from expansion or contraction. Provision for proper loops, offsets, or expansion joints to be responsibility of Contractor. Make provision for servicing and removal of equipment without dismantling piping.

N. Grooved joints shall be installed in accordance with the manufacturer's published installation instructions. The coupling manufacturer's factory trained representative
shall provide documented on-site training for the contractor’s field personnel in the use of grooving tool and installation of grooved joint products.

3.2 FIRE-RATED PARTITIONS

A. Provide permanent firestop system at all piping penetrations of fire-rated walls and floors. Review details on drawing as well as this specification for permissible firestop systems. The firestop system shall have been tested and approved in accordance with ASTM E119 and U.L. 1479 (ASTM E814) and classified for up to 2 hours fire rating. Firestop system shall be type detailed on drawings or intumescent type capable of expanding up to 8 times its original volume. Firestop system to be 3M, Hilti, Nelson, Johns Manville, or Specified Technologies. Firestop system shall be installed in strict accordance with published U.L. approved installation instructions. Piping to pass through the fire-rated partition insulated or non-insulated as specified and detailed. Submit U.L. approved installation drawing for each type of penetration prior to construction.

3.3 NON-RATED PARTITIONS

A. Piping to pass through the walls insulated or non-insulated as specified. Wall should be finished to fit neatly around the piping. Firestopping is not required at non-rated partitions.

3.4 PIPE SLEEVES

A. Pipe sleeves shall be provided at non-rated partitions and floor penetrations. Pipe sleeves to be Schedule 40 or 18 gage steel. Sleeves to extend 1-1/2" in excess of partition depth on each side. Sleeves penetrating floors in wet areas, including all mechanical rooms, shall extend a minimum of 1 inch above the floor.

1. Piping requiring sleeves:
   a. Heating hot water
   b. Chilled water
   c. Copper pipes thru masonry walls

3.5 PIPING IN TRANSFORMER, ELECTRICAL, AND ELEVATOR EQUIPMENT ROOMS

A. Refer to drawings. No water piping permitted in transformer, electrical, or elevator equipment rooms.

3.6 VALVE ACCESS

A. Locate all shutoff and control valves for easy access and operation. Where valves must necessarily be located in enclosed spaces, they shall be provided with access panels of sufficient size for operation. Furnish these access panels to proper trades for installation.
3.7 AIR VENTING
   A. Provide manual air vents at high points of vertical risers and at each water coil to eliminate air from HVAC water systems.

3.8 WATER DRAINING
   A. Provide 3/4" hose end gate valves at low points and bottom of each riser to drain HVAC water systems.

3.9 CONTROL SYSTEM CONNECTORS
   A. Weld 1" steel half coupling Crane No. 386 or equal, or provide 1" female pipe thread connection at points shown on drawings and at necessary points for installation of thermometers and automatic controls.

3.10 COOLING TOWER BLEED-OFF
   A. Provide bleed-off line with a "Y" type cleanable strainer in the discharge line to cooling tower as shown on drawings. Make connection above basin water line elevation of tower in vertical section of pipe and extend bleed line to within 2" of drain. Drill capped end to bleed 1% of the condenser water circulated gpm. Provide solenoid valve in bleed line as part of the chemical feed system.

3.11 RECIRCULATING PUMP BLEED
   A. Recirculating spray pumps shall have bleed line in discharge of pump.

END OF SECTION 232113
PART 1 GENERAL

1.1 WORK INCLUDED

A. Refrigeration piping, valves and fittings to connect remote condensers to heat pump air conditioning systems including computer room air conditioning systems.

1.2 SAFETY CODE

A. Comply with the requirements of ANSI B9.1, Code for Refrigerant Systems.

PART 2 PRODUCTS

2.1 MATERIALS

A. Piping: Type "L" ACR hard copper, ASTM B88.

B. Fittings: Wrought copper.

C. Solder: Silver solder, or phos-copper solder having a melting point of 1125 degrees F. or higher.

2.2 EQUIPMENT

A. Service Valves: Henry valves or equal. Provide packed type receiver, purge, and gauge valves with valve stem seal cap ports.
   1. Valves up to 5/8" O.D.: Henry Figure 516 or equal, diaphragm type.
   2. Valves larger than 5/8" O.D.: Henry Figure 203 or equal.

B. Solenoid Valves: Manufactured by Sporlan Co., or equal, suitable for the type of refrigerant used, and of a type permitting manual lifting of stem for emergency operation. Size valves for pressure drop of 3 pounds at design flow.

C. Refrigerant Filter Dehydrator: Sporlan Co. Filter-Drier or equal sealed core type of size recommended by manufacturer for maximum design tonnage. For systems 20 nominal tons and larger, provide replaceable core filter driers.

D. Moisture Indicator: Sporlan Co. See-All type SA-125 or equal.

E. Pipe Supports:
   1. Pipes subject to vibration: Isolation type brackets.
   2. Pipes not subject to vibration: Grinnell No. CT-95 or equal.
3. Riser clamps: Grinnel CT-121 or equal.

F. Escutcheons: Chrome plated escutcheons sized for pipe.

G. Insulation: Insulate piping as specified in Section 230710.

PART 3 EXECUTION

3.1 INSTALLATION

A. Make solder joints with carbon dioxide or nitrogen passing through joints being soldered. Ensure a clean, tight system. Pull a clean rag through each piece of tubing after cutting or reaming.

B. Install pipe and hangers in accordance with hanger manufacturers’ printed instructions.

C. Provide escutcheons at all visible wall penetrations in finished areas.

3.2 LEAK TESTING

A. Test for leaks by use of carbon dioxide or nitrogen and a liquid soapsuds solution. Correct leaks found.

B. Evacuate system to 20” vacuum and charge with refrigerant until a pressure of 15 psig is reached. Then test for leaks using a Halide leak detector. Correct leaks found.

C. Pressurize system, with carbon dioxide or nitrogen, to 300 psig on the high side, and 200 psig on the low side, and test for leaks. Correct leaks found.

3.3 SYSTEM DEHYDRATION

A. Dehydrate system by "Double Dehydration" method.

B. Use a suitable vacuum pump. Evacuate system to a vacuum of 0.2” Hg absolute and operate pump for eight hours when that pressure is reached.

C. After eight hours, admit dry nitrogen directly to the system, and then evacuate system to a vacuum of 0.2” Hg absolute and operate pump for four hours.

3.4 CHARGING SYSTEM

A. When system dehydration is complete and all leaks are corrected, charge system with refrigerant.

END OF SECTION 232300
SECTION 233110
SHEET METAL DUCTWORK - LOW PRESSURE

PART 1 GENERAL

1.1 WORK INCLUDED

A. Low pressure ductwork refers to systems operating at 2.00" w.g. total static pressure with velocities up to 2000 FPM. It is the intent of this specification to provide an installed duct system which will supply the air quantities indicated by the plans and have the lowest possible friction loss with the least possible leakage loss. Friction loss for each system shall not exceed that which is indicated in the A.C. unit schedule as external static pressure or in the fan schedule as static pressure and shall include the losses of all accessories. Friction losses shall be minimized by reduction in the number of offsets and elbows by pre-planning the duct system installation and coordination with other trades to prevent interferences. Access to all accessories requiring maintenance, service and inspection shall be maintained. Radius elbows are preferred for all turns to minimize friction, noise and vibration; and, especially, for sections having large volume or higher velocities and sections which may have turbulences.

B. The contractor shall provide and/or construct all materials, ductwork, joints, transitions, splitters, dampers, access doors, etc., as set forth in these specifications necessary to install the Low Pressure Sheet Metal Ductwork required by the Mechanical Drawings.

C. Low pressure ductwork shall be constructed to meet the following pressure class:
   1. Supply ductwork downstream of terminal units: 1.0" pressure class.
   2. Supply and return duct connections to fan coil units or single zone air systems (ESP ≤1.0") : 1.0" pressure class.
   3. Supply and return duct connections to fan coil units or single zone air systems (ESP >1.0", ≤2.0") : 2.0" pressure class.
   4. Exhaust and return ductwork (Fan ESP ≤2.0") : 2.0" pressure class.

1.2 QUALITY CONTROL AND REGULATORY STANDARDS

A. SMACNA Manual: Sheet Metal Tradesman is to have access on the construction site to the Latest Edition of SMACNA "HVAC Duct Construction Standards", (Metal and Flexible). The Manual is referred to in specifications for required construction methods and details. Contractor shall comply with provisions of the SMACNA Manual and more stringent requirements of this specification.

B. Quality control involves not only the general performance requirements for all air ducts, but also quality workmanship which includes layout preplanning so that offsets, rises, falls, elbows, fittings, etc., are minimized or eliminated. General performance requirements for all ducts include:
   1. Dimensional stability (shape deformation and strength).
2. Containment of the air being conveyed (leakage control).
3. Vibration (fatigue and appearance).
4. Noise (generation, transmission or attenuation).
5. Exposure (to damage, weather, temperature extremes, flexure cycles, wind, corrosive atmospheres, biological contamination, flow interruption or reversal, underground or other encasement conditions, combustion, or other in-service conditions).
7. Thermal conductivity (heat gain or loss and condensation control).

C. Provide galvanized duct materials which meet applicable requirements of SMACNA manual and local and state codes, whichever is the most stringent.

D. Support ductwork in accordance with applicable requirements of SMACNA manual, local and state codes, and details on plans, whichever is the most stringent.

E. Emboss fittings with material gauge, manufacturer, and type material.

F. Ductwork shall be installed to comply with the roof ceiling assembly for this project shown on Architectural Drawings, in accordance with the UL Fire Resistance Index Catalog.

G. Materials used as sealers, liners, pre-insulated jackets and flexible ducts shall comply with a flame spread rating of 25 or less and a smoke developed rating of not over 50.

H. Joint sealer shall meet the requirements of UL181A or UL181B as applicable.

I. Duct sealant classification: Seal all transverse joints, longitudinal joints and duct wall penetrations in accordance with SMACNA Class A.

1.3 SUBMITTALS AND SHOP DRAWINGS

A. Submit material/product data to designer for approval ONLY when it deviates from products specified in Part 2 herein.

B. Shop Drawings: Contractor to submit to owner for approval complete sheet metal shop drawings of all ductwork, including equipment rooms, shafts, and especially congested areas and areas with possible conflicts. No installation shall proceed without owner stamped approval of shop drawings. Submittal to reflect space requirements coordinated with other trades such as Electrical, Plumbing, Mechanical and Structural. Prior to submission to owner, shop drawings to have stamped approval of all major trades which occupy ceiling space (HVAC, plumbing, piping, sprinkler, and electrical), to substantiate adequate coordination as to space, accessibility and to ensure no conflict exists between contractors.

C. The General Contractor shall be responsible for coordination between trades and shall stamp and sign the duct drawings to substantiate that the coordination has been accomplished. Non-critical piping and conduit shall give way to ducts.
PART 2 PRODUCTS

2.1 MATERIAL

A. Sheet Metal, Angles, Bar Slips, Hangers, and Straps: Galvanized steel.

B. Screws: Cadmium plated.

   1. Stage 1: Apply fiber DT tape.
   2. Stage 2: Brush on RTA-50 sealant over fiber tape.

2.2 FABRICATION

A. Provide a rectangular or round duct where required on drawings of prime quality galvanized steel sheets, thickness and reinforcement as required by the following schedule, SMACNA, or local and state codes, whichever is more stringent. When fabricating low pressure ductwork, largest duct dimension governs the entire duct and complete joint.

<table>
<thead>
<tr>
<th>MAXIMUM DUCT DIMENSION (IN.)</th>
<th>DUCT GAUGE</th>
<th>SLIP GAUGE</th>
<th>STANDINGS</th>
<th>REINFORCEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up thru 18</td>
<td>24</td>
<td>24</td>
<td>- -</td>
<td>- -</td>
</tr>
<tr>
<td>19 - 30</td>
<td>24</td>
<td>24</td>
<td>1 x 24 ga.</td>
<td>No</td>
</tr>
<tr>
<td>31 - 42</td>
<td>22</td>
<td>22</td>
<td>1 x 24 ga.</td>
<td>No</td>
</tr>
<tr>
<td>43 - 54</td>
<td>22</td>
<td>22</td>
<td>1-1/2 x 20 ga.</td>
<td>1-3/8 x 1/8 Band Iron</td>
</tr>
<tr>
<td>55 - 60</td>
<td>20</td>
<td>20</td>
<td>1-1/2 x 20 ga.</td>
<td>1-3/8 x 1/8 Band Iron</td>
</tr>
<tr>
<td>61 - 84</td>
<td>20</td>
<td>20</td>
<td>1-1/2 x 18 ga.</td>
<td>1-1/2 x 1-1/2 x 1/8 Angle</td>
</tr>
<tr>
<td>85 - 96</td>
<td>18</td>
<td>20</td>
<td>1-1/2 x 18 ga.</td>
<td>1-1/2 x 1-1/2 x 3/16 Angle</td>
</tr>
<tr>
<td>Over 96</td>
<td>18</td>
<td>20</td>
<td>2 x 18 ga.</td>
<td>2 x 2 x 1/4 Angle</td>
</tr>
</tbody>
</table>

B. Duct dimensions shown on drawings indicate inside clear dimensions. Make allowances in sheet metal size for duct requiring internal duct liner to provide "inside clear" dimensions.

C. In addition to the requirements above, add supplemental bracing as necessary to prevent sagging, drumming, and vibration.

D. Round prefabricated 26 gauge slip joint duct may be used on exhaust and return duct 12" and smaller and for runout duct to boxes, diffusers, registers, and grilles.
   1. Secure duct sections and fittings with sheet metal screws.
   3. Transverse and longitudinal slip joints shall be sealed with approved sealer.
E. Provide transverse joints of "s" and drive construction at least every eight feet on duct whose larger side is less than 18". Seal all transverse joints with joint sealant material.

F. Provide transverse joints, or equivalent supplemental angle reinforcing on 4 foot centers on duct whose larger side is greater than 18". At the contractor's option, duct mate or equal joint system may be substituted for "s" and drive construction. Seal all transverse joints with joint sealant material.

G. Longitudinal seams shall be Pittsburg Lock or grooved seams closed tightly and evenly. Button punch snap lock longitudinal seam construction shall not be allowed. Seal longitudinal joints which prove to leak with joint sealant material.

H. Cross break ductwork over 10" dimension, either side.

I. Do not exceed 20 degree angle of slope for increase-in-area transitions.

J. Do not exceed 20 degree angle of slope for decrease-in-area transitions.

K. Do not exceed 30 degrees on the entering side or 45 degrees on the leaving side for angle of transitions at connections to equipment without the use of approved vanes. 20 degree angle is preferred and should be used space permitting.

L. Provide Ells fabricated to one of the following specifications in order of preference (SMACNA Figures 4-2 through 4-4 and Figure 4-9 and Chart 4-1):
   1. Unvaned elbow with the throat radius equal to 3/4 of the width of the duct and with a full heel radius.
   2. Six inch throat radius with full radius, single thickness vanes and full heel radius. Maximum unsupported length of vanes shall be 36". Vanes shall be securely fastened to runners. All vanes shall be secure and stable in installed operating position. Construct vane edges to project tangents parallel to duct sides.
   3. Square elbows with single thickness turning vanes. Maximum unsupported length of vanes shall be 36". Vanes shall be securely fastened to runners. All vanes shall be secure and stable in installed operating position. Construct vane edges to project tangents parallel to duct sides.
   4. Radius elbows are the preferred fitting. Square elbows are to be used only when available space prevents the use of radius elbows.

M. Provide offsets as necessary in accordance with SMACNA Figure 4-7.

N. Make branch connections and tees in one of the following manners:
   1. Converging radius elbow with MVD. (SMACNA Figure 4-5).
   2. 45-degree entry with MVD. (SMACNA Figure 4-6).
   3. Round spin-in fitting with MVD.

O. Space duct joints to avoid cutting them for branch take offs and outlet collars.
2.3 INTERNAL DUCT LINER

A. Liner: 1" thick (unless otherwise indicated on drawings), UL listed, neoprene coated, mat faced, flexible fiberglass of one pound per cubic foot density.

B. Provide liner that complies with UL 181 Erosion Test and has a flame spread rating of 25 or less and a smoke developed rating of 50 or less.

C. Adhere liner to the duct with a continuous coating of approved adhesive and with adhesive clips or welded studs on 16" centers.

D. Provide coating of CP30 low odor on air entering side and seal other joints with metal or fiberglass cloth so that liner will be smooth to air flow.

E. Interrupt liner 18" upstream and 30" downstream at each duct mounted electric heater. Apply 1" thick rigid board type duct insulation externally on this section of duct, overlapping lined sections at least 6".

F. The leading edge of the duct liner (at the AHU, and after fire dampers) shall be protected with sheet metal nosing. This will help ensure proper protection of the leading exposed duct liner edge from erosion and or delamination (see SMACNA HVAC Duct Construction Standards, 3rd Edition, Section 2.9 of Chapter 7.4).

PART 3 EXECUTION

3.1 INSTALLATION, APPLICATION, ERECTION

A. Support ductwork on each side of the duct with suitable sheared strips of galvanized metal or 1" x 1/8" galvanized steel band iron hangers.

B. Attach hangers to the ductwork using sheet metal screws.

C. Secure hangers to concrete structure with approved anchor shields and to steel structure by means of C-clamps.

D. Space hangers approximately eight feet along the duct except as noted below.

E. For ducts 60" and larger and heavy sections, such as welded duct and sound absorbers, space hangers at approximately four foot intervals.

F. Obstructions shall not be located within ducts.

G. Do not exceed 45 degrees for easement transition angle.

H. Seal all transverse joints with approved sealer in accordance with manufacturers' directions. Also, seal longitudinal joints which prove to leak.
I. Insulation: Where drawings and insulating specifications indicate that ducts are to be insulated make provisions for neat insulation finish around damper operating quadrants, splitter adjusting clamps, access doors, and similar operating devices. Metal collar equivalent in depth to insulation thickness and of suitable size to which insulation may be finished to be mounted on duct.

J. Counterflashing: Counterflash all ducts where they pierce the roof.

K. Pitot Ports: Pitot ports for measuring airflow to be located in each main duct at the downstream end of the straightest run of the main and before the first branch take-off. Pitot ports to be formed by drilling 7/16” holes in the duct, lined up perpendicular to airflow on maximum 8” centers and at least three to a duct, evenly spaced. Holes to be plugged with plastic plugs. Provide access to these for future rebalancing.

3.2 CLEANING

A. Clean ductwork thoroughly to assure all foreign matter, dirt, etc. is removed.

3.3 LEAKAGE TESTING OF INSTALLED SYSTEMS

A. Test Low Pressure Ductwork as follows:
1. Follow procedure published by United Sheet Metal Division of United McGill Corporation entitled “System Pressure Testing for Leaks” using prescribed test kit containing test blower, two U-tube manometers, and calibrated orifice tube.
2. Installed low pressure duct system to be pressurized to 50 percent over design operating pressure or 2” w.g. whichever is greater. Air leakage at test pressure to be measured by a calibrated orifice type flow meter. Total allowable leakage of system shall not exceed 1/2 of 1 percent of system air handling capacity. If system is tested in sections, leakage rates to be added to give performance of whole system.
3. Leakage concentrated at one point may result in objectionable noise even if system passes leakage rate criteria; correct to satisfaction of Designer.
4. Orifice flow measurement device to be individually calibrated against a primary standard and calibrated curve permanently attached to orifice tube assembly.
5. Leak testing shall be observed by the General Contractor’s on-site quality control representative. The contractor shall have on site at all times the duct leak test training video distributed by the Owner. Maintain on site a set of prints to identify, in different colors, the duct sections isolated for each test, as well as the date of the leak test and final leakage rate recorded for each duct section.

END OF SECTION 233110
PART 1 GENERAL

1.1 WORK INCLUDED

A. Specialties to be submitted and approved before starting installation.

B. Items to be installed approximately as shown on drawings taking into account differences in mechanical equipment submitted and that shown on contract documents. Each item to be installed so that it is readily accessible for maintenance, repair, and/or setting and balancing.

C. Diffusers, registers, and grilles to have ratings certified by Air Diffusion Council and tested per ADC Equipment Test Code 1062R2 and ASHRAE Standard 36B-63.

D. Refer to drawings for diffuser, register, and grille sizes and number of airflow directions.

PART 2 PRODUCTS

2.1 FIRE DAMPERS

A. Fire dampers to be U.L. listed in accordance with UL-555. Fire dampers to be held in an open position with a 165 degree F fusible link and arranged to lock in position on closure.

B. Fire dampers for rectangular duct to be type "B" (Blades out of air stream) and for round duct to be Type "C" (Blades and frame out of air stream). Fire dampers located behind sidewall registers and grilles and others specifically indicated on drawings to be Type "A" (Frame and Blades in air stream). Fire dampers to be multi-leaf type with spring closing for horizontal mounting and weighted-gravity closing for vertical mounting. Dampers to be steel construction with rust resistant finish and provided with a factory-installed mounting sleeve suitable for structure. Mount per manufacturer's published U.L. approved installation instructions. Manufacturer models which provide square to round or round oval transitions are acceptable.

C. See Architectural drawings for hour-rating of walls and/or floors. Dampers to be compatible with hour ratings.

D. Fire dampers to be Ruskin Model IBD2 Curtain Type Static Fire Dampers.

E. Contractor to provide all first year testing, as required by NFPA 80, for all Fire Doors and Dampers.
2.2 COMBINATION SMOKE/FIRE DAMPERS

A. Combination smoke/fire dampers to be U.L. listed both as 1-1/2 hour fire damper under UL-555 and as smoke damper under UL-555S as Minimum Leakage Category II and Elevated Temperature Category B (350 degrees F).

B. Dampers to be steel construction with rust resistant finish and provided with 165 degree F electronic resettable fuse link (EFL) and factory-installed mounting sleeve suitable for structure. Mount damper per manufacturer’s published U.L. approved installation instructions.

C. Smoke detectors to be furnished by Division 26; coordinate wiring hook-ups. Damper operator to be electric type compatible with electrical characteristics used for smoke detection and/or fire alarm system.

D. Dampers to be Ruskin Model FSD35 with crimped type blades for low-pressure duct systems and Ruskin Model FSD60 with airfoil blades for medium- and high-pressure duct systems.

2.3 SMOKE DAMPERS

A. Smoke dampers to be U.L. listed in accordance with UL-555S as Minimum Leakage Category II and Elevated Temperature Category B (350 degrees F).

B. Dampers to be steel construction with rust resistant finish and provided with factory installed mounting sleeve suitable for structure. Mount damper per manufacturer’s published U.L. approved installation instructions.

C. Smoke detectors to be furnished by Division 26; coordinate wiring hook-ups. Damper operator to be electric type compatible with electrical characteristics used for smoke detection and/or fire alarm system.

D. Dampers to be Ruskin Model SD60 with crimped type blades for low-pressure duct systems and Ruskin Model SD60 with airfoil blades for medium- and high-pressure duct systems.

2.4 DAMPERS

A. Automatic Control Dampers: All automatic control dampers to be furnished by Control Subcontractor and installed by this Contractor (except unit mounted dampers).

1. Automatic control dampers to be low-leak, galvanized steel or aluminum construction parallel blade type, Ruskin Model CD36, Arrow Series 395, or approved equal.

2. Dampers to be complete with minimum 4" deep, 16-gauge hat-shaped channel frame, minimum 16 gauge blades on maximum 6" centers, 1/2" diameter shafts, and corrosion resistant bearings.

3. Dampers to have extruded vinyl blade seals and stainless steel or aluminum flexible metal compression type jamb seals to limit leakage to a maximum of
1/2% (maximum of 5.4 cfm/sq. ft. leakage for 48" x 48" size damper) when tested in accordance with AMCA Standard 500.

4. Motor actuator to be oil immersed gear train, 120-volt line voltage type with spring return to closed position on power interruption. Provide Honeywell Model M445/845, Barber-Colman MA-5210/5330 or approved equal complete with damper linkages.

B. Manual Volume Dampers (MVD): Manual volume dampers to be hand-operated type dampers constructed of galvanized steel, minimum 22-gauge for duct widths 18" and less, minimum 16-gauge for duct widths greater than 18". Dampers for ducts to 12" height and 12" diameter to be single blade carried on a 3/8" round steel rod mounted inside of duct without frame and fitted with locking type quadrant and brass end bearing plate accurately drilled and secured to duct. Dampers for ducts greater than 12" height to be multi-blade type, 12" maximum blade width up to 30" blade length and 10" maximum blade width over 30" blade length. Blades to be mounted on frame with brass sleeve bearings interconnected for operation from one locking type hand quadrant. Round pivot rods to have section faced flat to receive locking setscrew in locking quadrant. Refer to SMACNA manual Figures 2-14 and 2-15.

1. Ductwork manual volume damper (MVD) handles in externally wrapped ductwork shall be supplied with a stand-off bracket and locking quadrant to ensure that the handle can be adjusted without disturbing the insulation vapor barrier.

2.5 SQUARE CEILING DIFFUSERS

A. Provide Titus Omni or approved equal round neck, square panel face ceiling diffusers at all locations designated by schedule on drawings. Diffusers to be steel or aluminum construction. Frame to be flush mount for diffusers in "hard" ceilings and lay-in T-bar mount for diffusers in lay-in ceilings. Finish to be baked-on, off-white enamel.

2.6 SIDEWALL SUPPLY REGISTERS

A. Provide Titus 272-FL5 or approved equal at locations designated by "SAR". Registers to be all aluminum construction complete with individually adjustable, double deflection airfoil blades spaced 3/4" with front set of blades horizontal. Finish to be baked-on, off-white enamel.

2.7 SIDEWALL RETURN REGISTERS

A. Provide Titus 1700 or approved equal at all locations designated by "RAR". Registers to be all aluminum construction complete with removable and rotating fixed horizontal blade core. Finish to be baked-on, off-white enamel. Border to be curved, Titus Type "C".

2.8 CEILING RETURN & EXHAUST REGISTERS

A. Provide Titus Model 50-F or approved equal at locations designated by schedule on drawings. Registers to be complete with 1/2" cube egg-crate aluminum grid. Finish to be baked-on, off-white enamel. Border to be flush mounted frame style.
2.9  CEILING FILTER GRILLE

A. Provide Titus 50-FF or approved equal filter grille at all locations indicated on drawings. Grilles to be complete with 1/2" cube eggcrate aluminum grid, hinged face and frame to hold 1" thick filter. Finish to be baked-on, off-white enamel. Border to be lay-in style for T-bar lay-in ceilings and surface style for rigid ceilings or exposed application. Filters to be 1" thick, 30 percent medium-efficiency Farr 30/30 or approved equal disposable type.

2.10  AIR LOUVERS

A. Air louvers shall be stationary horizontal, wind driven rain, extruded aluminum blades equal to Greenheck model EHH-601. The louvers shall be AMCA Certified. Louvers to be have minimum 0.081" thick aluminum frame and blades. Louver depth to be 6" with blades on approximate 2" spacing. Blade construction to be horizontal rain resistant style. Finish shall be Kynar color selected by Architect. Manufacturer will submit metal color chip to Architect as part of the submittal approval. Louver shall be rated at: the beginning point of water penetration (0.01 oz. of water (penetration) per sq. ft. of louver free area is above 1,250 fpm, minimum 46% free area, 0.21" S.P. resistance at 1,000 fpm. Provided 1/2" mesh expanded aluminum screen with removable frame mounted on inside face of louver. Provide minimum 10 year finish warranty.

2.11  FLEXIBLE CONNECTORS

A. Install UL listed flexible duct connectors between duct and fan/equipment connections. Flexible duct connectors to be made of 28-ounce, heavy glass fabric double coated with neoprene.

2.12  FLEXIBLE DUCT

A. Flexmaster Type 1M Acoustical Attenuating or Approved equal. Submit acoustical performance of any alternate product for prior approval.
   1. Characteristics of flexible duct:
      a. Approved as UL-181 Class 1 air duct.
      b. Flame spread rating less than 25 and smoke developed rating less than 50.
      c. Rated for 6" w.g. positive pressure, 4" w.g. negative pressure, and 5000 fpm air velocity.
      d. Tear and puncture resistant reinforced CPE inner liner mechanically locked together with a corrosive resistant galvanized steel helix.
      e. Insulated with minimum 1/2" thick fiberglass insulation with vapor barrier jacket.

B. Seal off the insulation jacket at its ends and at joints with mastic, Hardcast, or similar material. Replace flexible duct if jacket is punctured.

C. Flexible duct is NOT to be used for runouts where it must pass through walls or through smoke or fire partitions. Flexible duct is not to be used in exposed application. Flexible duct lengths shall not exceed 6 feet at each connection.
D. No bends shall be made in flexible duct with the center line radius less than one and one-half duct diameter and only one bend may occur per 6 foot length of duct material.

2.13 DUCT ACCESS DOORS

A. Duct access doors to be provided for access to all coils, fire, fire/smoke, and smoke dampers, automatic and backdraft dampers, duct smoke detectors, static pressure and air volume sensing devices, and other equipment installed in ducts and at other points indicated on drawings.

B. Access door construction and airtightness must be suitable for the duct pressure class used (low, medium, or high).

C. Access doors to be double-panel, galvanized steel construction with minimum 1” rigid insulation between panels. Access doors in exhaust duct and unlined return duct may be uninsulated single panel, galvanized steel construction. Doors to mount in rigid frame constructed of formed galvanized steel. Angle iron bracing to be used as required to provide rigid assembly. Doors to hinge on one side with door latch on opposite side.

D. Access doors in ductwork shall fully comply with Figure 2-12 and 2-13 of SMACNA manual. Casing access doors shall fully comply with Figure 6-11 and 6-12 of SMACNA manual.

E. Doors to close against gasket seal.

F. Access doors for fire dampers, fire/smoke dampers, and smoke dampers shall be permanently identified on the exterior by a label having letters not less than 0.5 inches in height reading: “Fire Damper” “Fire/Smoke Damper” or “Smoke Damper” as required by 2012 International Mechanical Code.

PART 3 EXECUTION

3.1 INSTALLATION

A. Installation to be in accordance with manufacturers’ published installation instructions as well as applicable sections of SMACNA manual.

B. Provide all screws, bolts, nuts, and inserts required for attaching sheet metal specialty items to ducts, walls, floors and ceilings.

END OF SECTION 233310
PART 1 GENERAL

1.1 WORK INCLUDED

A. Provide packaged heat recovery air conditioning units as manufactured by AAON, or equal by Addison, Trane or Valent.

1.2 QUALITY ASSURANCE

A. Unit cooling capacity shall be in accordance with and tested to AHRI Standard 210/240 or 360.

B. Units up to 20 tons capacity shall carry the AHRI compliance label.

C. Units shall be safety certified in accordance with UL Standard UL465 and ANSI Standard Z21.47.

D. Unit shall be safety certified by an accredited testing laboratory. Unit nameplate shall carry the label of the certification agency.

E. Unit shall be shipped completely assembled by the manufacturer including all standard items and accessory items.

F. Unit shall be 100 percent run tested by the manufacturer with a copy of the run test report shipped with the unit.

PART 2 PRODUCTS

2.1 EQUIPMENT

A. Unit Construction:
   1. Unit shall be completely factory assembled, piped, wired and shipped in one piece.
   2. Unit shall be specifically designed for outdoor application with a fully weatherproof cabinet.
   3. Unit shall be designed for mounting on a slab-on-grade mounted curb.
   4. Cabinet shall be constructed entirely of G90 galvanized steel with the exterior constructed of 18 gauge or heavier material.
   5. The unit roof shall be cross broken and/or sloped to assure drainage.
   6. Access to compressor(s), controls, filters, fan(s), heating section, and other items needing periodic checking or maintenance shall be through hinged access doors with a quarter turn latch (door fastening screws are not acceptable).
7. Air side service access doors shall be fully gasketed with rain break overhangs. Air side access doors shall have an internal metal liner to protect the door insulation.

8. Unit exterior shall be painted with 2-part polyurethane paint over a wash primer and a paint grip type galvanized steel.

9. The interior side of all exterior panels shall be entirely insulated with 1” thick, one pound density, neoprene coated, fiberglass insulation.

10. Unit shall be provided with interior insulation liners to provide double wall construction.

11. All openings through the base pan of the unit shall have upturned flanges of at least 1/2” in height around the opening through the base pan.

12. Unit shall have decals and tags to indicate unit lifting rigging, service areas, and caution areas.

13. Wiring diagrams shall be both "point-to-point" and "ladder" diagrams. Wiring diagrams shall also be laminated in plastic and permanently fixed to the control compartment door.

14. Wiring shall be color coded and marked with identification on each end.

B. Fans:

1. Fan(s) shall be entirely self-contained on a slide deck for service and removal from the cabinet.

2. All motors 1 horsepower and larger shall have belt-driven fans. All motors less than 1 horsepower shall have direct-driven fans. Belt-driven fan(s) shall have backward inclined airfoil blades. Adjustable v-belt drive shall be provided with a minimum rating of 140 percent of the motor nameplate brake horsepower when the adjustable pulley is at the minimum RPM. Direct-driven fan(s) shall have forward curved blades.

3. Fans, drives, and motors shall be dynamically balanced.

C. Condensing Section:

1. The condensing section shall be equipped with direct-drive, vertical discharge condenser fan(s).

2. The condenser coil shall be sloped at least 30 degrees from horizontal to protect the coil from damage. If condenser coil is not sloped for protection, louvered coil guards shall be provided.

3. Condenser coil(s) shall be copper tubes with aluminum fins mechanically bonded to the tubes.

4. Condenser coil(s) to be sized for a minimum of 10 degrees sub-cooling.

D. Evaporator Coil:

1. Evaporator coil shall be minimum 6 rows.

2. Evaporator coil(s) shall be copper tubes with aluminum fins mechanically bonded to the tubes.

3. Evaporator coil(s) shall have galvanized steel end casings.

4. Evaporator coil(s) shall have equalizing type vertical tube distributors with a top suction connection.

5. Evaporator coil(s) for multi-compressor units shall be circuited with one circuit and expansion valve per compressor.

6. Unit shall be provided with stainless steel drain pan.
E. Refrigeration System:
1. Compressor(s) shall be of the hermetic scroll type with internal thermal overload protection.
2. All units over 7-ton capacity shall be multiple stage and shall have a minimum of two stages of capacity control.
3. Compressor(s) shall be mounted in an isolated compartment to permit operation of the unit without affecting airflow when the compressor compartment is open.
4. Compressor(s) shall be isolated from the base pan and supply air to avoid any transmission of noise from the compressor into the building area.
5. System shall be equipped with thermostatic expansion valve type refrigerant flow control.
6. System shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant controls.
7. Unit shall be equipped with Schrader type service fittings on both the high side and low pressure sides of the system.
8. Unit shall be equipped with refrigerant liquid line filter driers.
9. Unit shall be fully factory charged with refrigerant R-410.
10. 5-year compressor warranty shall be provided.
11. Unit shall be provided with 35 degree F low ambient control.
12. Unit shall be provided with hot gas bypass on each refrigerant circuit.
13. All circuits shall be equipped with liquid line sight glass.

F. Dehumidification: Unit shall be provided with factory-mounted minimum 15 degree F hot gas reheat coil piped to the lead refrigerant system and all necessary refrigerant piping, valves, and controls.

G. Gas Heating:
1. Units shall be provided with a gas heating furnace using natural gas fuel consisting of a tubular stainless steel heat exchanger with 25-year warranty, an induced draft blower, and an electric pressure switch to lock out the gas valve until the combustion chamber is purged and combustion airflow is established.
2. Unit shall be provided with an electronic gas ignition system.
3. Unit shall have gas supply piping entrances in the unit base for through the curb gas piping and in the outside cabinet wall for across the roof gas piping.
4. Unit shall be provided with modulating gas heat control.
5. Unit shall have gas pressure regulator capable of reducing 2 psi gas inlet pressure to 7” w.c.

H. Outside Air:
1. Outside air shall be 100 percent with an adjustable motor-operated outside air damper constructed of extruded aluminum blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 25 cfm of leakage per square foot of damper area when subjected to 2” w.g. air pressure differential across the damper. Damper motor shall be spring return to ensure closing of outside air damper during periods of unit shutdown or power failure.
I. Filters:
   1. Unit shall be provided with 2" thick, 30 percent medium-efficiency pleated, throwaway supply air filters.
   2. Provide filter gauge.

J. Electrical:
   1. Unit shall be provided with a factory installed and wired internal non-fused disconnect switch.
   2. Unit shall be provided with a factory installed and factory wired 115-volt, 13-amp ground fault service receptacle.

K. Controls:
   1. Provide terminals for connection to controls provided under separate controls section.
   2. Provide unit mounted make-up air programmable microprocessor controller with On-Off hot gas reheat to control discharge air temperature and humidity conditions based on outside air temperature and humidity conditions. Provide with discharge air temperature sensor and outside air temperature and humidity sensors.
   3. Provide unit mounted make-up air programmable microprocessor controller with proportional hot gas reheat to control discharge air temperature and humidity conditions based on outside air temperature and humidity conditions. Provide with discharge air temperature sensor and outside air temperature and humidity sensors. Provide space/return air temperature reset.
   4. Provide one hand-held service tool with keypad and LCD display to communicate with unit programmable controller and allow user to view any temperature or output condition and change any setpoint for any unit. Turn service tool over to Owner at project completion. Start up and verify unit controls and system manager are operating properly.
   5. Provide one system manager with keypad and LCD display to communicate with unit programmable controller and allow user to view any temperature or output condition and change any setpoint for any unit. Locate system manager on wall in space indicated on drawings. Connect system manager to each unit controller with 2-conductor twisted pair with shield (Beldon #82760 or equal) per manufacturers’ published installation instructions. Start up and verify unit controls and system manager are operating properly.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install unit in accordance with manufacturers’ published installation instructions.

B. Manufacturers’ representative service technician to provide start-up supervision for each unit.
C. Duct connections to units to allow for straight and smooth airflow. Connections to unit to be made with flexible duct connections. Sleeve duct penetrations through roof. Provide three 2" layers of neoprene coated fiberglass duct liner to completely fill inside of roof curb.

D. Drain lines to be trapped and run full size from drain pan connection to discharge as indicated on plans.

END OF SECTION 237520
PART 1 GENERAL

1.1 SYSTEM DESCRIPTION

A. Simultaneous Heating and Cooling Heat Pump: The VRF (Variable Refrigerant Flow) system shall be a simultaneous cooling and heating heat pump. The simultaneous heating and cooling VRF system shall consist of an outdoor unit, high efficiency heat recovery units designed for minimum piping and maximum design flexibility, indoor units, and controls by the equipment manufacturer. Every indoor unit shall be independently capable of operating in either heating or cooling mode regardless of the mode of other indoor units. The system shall be capable of changing mode of individual indoor units (cooling to heating or heating to cooling) within a maximum time of 5 minutes to ensure indoor temperature can be properly maintained.

1.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Alternate manufacturers: Daikin, Mitsubishi, LG, Trane, Toshiba-Carrier or Sanyo.

B. All manufacturers other than the basis of design are required to coordinate all manufacturer specific requirements with all associated trades. Any additional costs associated with the alternate equipment including but not limited to electrical wiring costs, piping costs, insulation, ceiling systems coordination and engineering design costs shall be covered by the equipment manufacturer and subcontractor. No additional costs shall be incurred by the owner or designer.

1.3 QUALITY ASSURANCE

A. The units shall be listed by Electrical Laboratories (ETL) and bear the ETL label.

B. All wiring shall be in accordance with the National Electrical Code (N.E.C.).

C. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).

D. A full charge of R-410A for the condensing unit only shall be provided in the condensing unit.
E. The VRF system shall be installed by a licensed mechanical contractor trained by the VRF equipment manufacturer or certified manufacturer’s agent.

F. Commissioning shall be performed by the manufacturer or certified manufacturer’s agent.

1.4 STORAGE AND HANDLING

A. All VRF equipment shall be stored protected from weather, extreme temperature, etc. as suggested by the manufacturer. All VRF equipment shall be moved, lifted, etc. as suggested by the manufacturer.

1.5 WARRANTY

A. VRF equipment shall be warranted by the manufacturer’s limited warranty for a period of one year from date of substantial completion. Manufacturers shall provide an extended warranty including 1 additional year parts and 5 additional year's compressor.

PART 2 PRODUCTS

2.1 SIMULTANEOUS HEATING AND COOLING OUTDOOR UNIT

A. General: The outdoor unit shall be used specifically with manufacturer approved piping components and air handling units. The outdoor units shall be equipped with multiple circuit boards that interface to the VRF controls system and shall perform all functions necessary for operation. Each outdoor unit module shall be completely factory assembled, piped and wired and run tested at the factory.

1. All units requiring a factory supplied twinning kits shall be piped together in the field, without the need for equalizing line(s). If an alternate manufacturer is selected, any additional material, cost, and labor to install additional lines shall be incurred by the contractor.

2. Outdoor unit shall have a sound rating no higher than 60 dB(A) individually or 64 dB(A) twinned. Units shall have a sound rating no higher than 50 dB(A) individually or 53 dB(A) twinned while in night mode operation. If an alternate manufacturer is selected, any additional material, cost, and labor to meet published sound levels shall be incurred by the contractor.

3. All refrigerant lines from the outdoor unit to the BC (Branch Circuit) Controller (Single or Main) or heat recovery box shall be insulated.

4. Outdoor unit shall be able to connect to up to 50 indoor units depending upon model.

5. The outdoor unit shall have an accumulator with refrigerant level sensors and controls.

6. The outdoor unit shall have a high pressure safety switch, over-current protection, crankcase heater and DC bus protection.

7. The outdoor unit shall have the ability to operate with a maximum height difference of 164 feet and have total refrigerant tubing length of 1804-2625 feet.
The greatest length is not to exceed 541 feet between outdoor unit and the indoor units without the need for line size changes or traps.

8. The outdoor unit shall be capable of operating in heating mode down to -4 degrees Fahrenheit ambient temperature or cooling mode down to 23 degrees Fahrenheit ambient temperature, without additional low ambient controls. If an alternate manufacturer is selected, any additional material, cost, and labor to meet low ambient operating condition and performance shall be incurred by the contractor.

9. The outdoor unit shall be capable of operating in cooling mode down to -10°F with optional manufacturer supplied low ambient kit.

10. Manufacturer supplied low ambient kit shall be provided with predesigned control box rated for outdoor installation and capable of controlling kit operation automatically in all outdoor unit operation modes.

11. Manufacturer supplied low ambient kit shall be listed by Electrical Laboratories (ETL) and bear the ETL label.

12. Manufacturer supplied low ambient kit shall be factory tested in low ambient temperature chamber to ensure operation. Factory performance testing data shall be available when requested.

13. The outdoor unit shall not cease operation in any mode based solely on outdoor ambient temperature.

14. The outdoor unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained.

15. Unit must defrost all circuits simultaneously in order to resume full heating more quickly. Partial defrost which may extend “no or reduced heating” periods shall not be allowed.

16. Unit Cabinet: The casing(s) shall be fabricated of galvanized steel, bonderized and finished. Unit cabinets shall be able to withstand 960 hours per ASTM B117 criteria for seacoast protected models.

B. Fan:
1. Each outdoor unit module shall be furnished with one direct drive, variable speed propeller type fan. The fan shall be factory set for operation under 0 in. WG external static pressure, but capable of normal operation under a maximum of 0.24 in. WG external static pressure via dipswitch.
2. All fan motors shall have inherent protection, have permanently lubricated bearings, and be completely variable speed.
3. All fan motors shall be mounted for quiet operation.
4. All fans shall be provided with a raised guard to prevent contact with moving parts.
5. The outdoor unit shall have vertical discharge airflow.

C. Refrigerant
1. R410A refrigerant shall be used for all systems.
2. Contractor shall provide sufficient refrigerant to properly charge system.

D. Coil:
1. Each outdoor coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing.
2. The coil fins shall have a factory applied corrosion resistant blue-fin finish.
3. The coil shall be protected with an integral metal guard.
4. Refrigerant flow from the outdoor unit shall be controlled by means of an inverter driven compressor.
5. The outdoor coil shall include 4 circuits with two position valves for each circuit, except for the last stage.

E. Compressor:
1. Each outdoor unit module shall be equipped with one inverter driven scroll hermetic compressor. Non inverter-driven compressors shall not be allowed.
2. A crankcase heater(s) shall be factory mounted on the compressor(s).
3. The outdoor unit compressor shall have an inverter to modulate capacity. The capacity shall be completely variable with a turndown of 19%-5% of rated capacity, depending upon unit size.
4. The compressor will be equipped with an internal thermal overload.
5. The compressor shall be mounted to avoid the transmission of vibration.
6. Field-installed oil equalization lines between modules are not allowed. Prior to bidding, manufacturers requiring equalization must submit oil line sizing calculations specific to each system and module placement for this project.

F. Electrical:
1. The outdoor unit electrical power shall be 208/23 03-phase, 60 hertz.
2. The outdoor unit shall be capable of satisfactory operation within voltage limits of 187-228 volts (208/60Hz).
3. The outdoor unit shall be controlled by integral microprocessors.
4. Provide all manufacturer required control wiring between each unit outdoor unit and system controller. Control wiring shall be 2 conductor twisted pair shielded cable.

G. Multiple Condensing unit Sections
1. The outdoor unit shall be completely factory assembled, piped and wired. Dual and triple frame outdoor units will be field piped with factory designed and supplied Y-branch kits to manifold them together into a single refrigerant circuit.
2. The outdoor unit shall be modular in design and should allow for side-by-side installation with minimal spacing.
3. Multiple modules shall have duty cycling function to ensure sequential starting of each module at each start/stop cycle, completion of oil return, completion of defrost or every 8 hours of runtime.

2.2 BRANCH CIRCUIT (BC) CONTROLLERS / HEAT RECOVERY BOXES / SOLENOID VALVE KITS
A. General: Unit manufacturer shall provide branch circuit controller / heat recovery box / or solenoid valve kit as required by system to allow for simultaneous heating or cooling operation of any indoor fan coil unit.
B. The BC (Branch Circuit) Controllers shall be specifically used with manufacturer provided fan coil units. These units shall be equipped with a circuit board that interfaces to the VRF controls system and shall perform all functions necessary for operation. The unit shall have a galvanized steel finish. The BC Controller shall be
completely factory assembled, piped and wired. Each unit shall be run tested at the factory. This unit shall be mounted indoors, with access and service clearance provided for each controller. The sum of connected capacity of all indoor air handlers shall range from 50% to 150% of rated capacity.

1. BC Unit Cabinet:
   a. The casing shall be fabricated of galvanized steel.
   b. Each cabinet shall house a liquid-gas separator and multiple refrigeration control valves.
   c. The unit shall house two tube-in-tube heat exchangers.

2. Refrigerant: R410A refrigerant shall be required.

3. Refrigerant valves:
   a. The unit shall be furnished with multiple branch circuits which can individually accommodate up to 54,000 BTUH and up to three indoor units. Branches may be twinned to allow more than 54,000 BTUH.
   b. Each branch shall have multiple two-position valves to control refrigerant flow.
   c. Service shut-off valves shall be field-provided/installed for each branch to allow service to any indoor unit without field interruption to overall system operation.
   d. Linear electronic expansion valves shall be used to control the variable refrigerant flow.

4. See drawings for required quantity of zones for each system. All system alternate manufacturers shall provide identical quantity of cooling and heating zones per BC controller as shown on drawings. If alternate manufacturer unable to provide identical quantity then manufacturer shall provide additional BC controllers, wiring, and piping to provide same number of zones shown on the drawings at no additional cost.

5. Integral Drain Pan: An integral condensate pan and drain shall be provided.

6. Electrical:
   a. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.
   b. The unit shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253V (230V/60Hz).

7. The BC Controller shall be controlled by integral microprocessors.

8. The control circuit between the indoor units and the outdoor unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

2.3 4-WAY CEILING-RECESSED CASSETTE WITH GRILLE INDOOR UNIT

A. General: Unit shall be a four-way cassette style indoor unit that recesses into the ceiling with a ceiling grille. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function, a test run switch, and the ability to adjust airflow patterns for different ceiling heights. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.
B. Unit Cabinet:
1. The cabinet shall be space-saving ceiling-recessed cassette.
2. The cabinet panel shall have provisions for a field installed filtered outside air intake.
3. Branch ducting shall be allowed from cabinet.
4. Four-way grille shall be fixed to bottom of cabinet allowing two, three or four-way blow.
5. The grille vane angles shall be individually adjustable from the wired remote controller to customize the airflow pattern for the conditioned space.

C. Fan:
1. The indoor fan shall be an assembly with a turbo fan direct driven by a single motor.
2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
3. The indoor fan shall consist of five (5) speed settings, Low, Mid1, Mid2, High and Auto.
4. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set-point and space temperature.
5. The indoor unit shall have an adjustable air outlet system offering 4-way airflow, 3-way airflow, or 2-way airflow.
6. The indoor unit shall have switches that can be set to provide optimum airflow based on ceiling height and number of outlets used.
7. The indoor unit vanes shall have 5 fixed positions and a swing feature that shall be capable of automatically swinging the vanes up and down for uniform air distribution.
8. The vanes shall have an Auto-Wave selectable option in the heating mode that shall randomly cycle the vanes up and down to evenly heat the space.

D. Filter: Return air shall be filtered by means of a long-life washable filter.

E. Coil:
1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.
6. Both refrigerant lines to the indoor unit shall be insulated.

F. Condensate Pump: The unit shall be provided with an integral condensate lift mechanism that will be able to raise drain water 33 inches above the condensate pan.

G. Electrical:
1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).
H. Controls: This unit shall use controls provided by unit manufacturer to perform functions necessary to operate the system.

2.4 CEILING-CONCEALED DUCTED INDOOR UNIT

A. General: Unit shall be a ceiling-concealed ducted indoor fan coil design that mounts above the ceiling with a 2-position, field adjustable return and a fixed horizontal discharge supply and shall have a modulating linear expansion device.

B. Indoor Unit. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

C. Unit Cabinet:
   1. The unit shall be, ceiling-concealed, ducted.
   2. The cabinet panel shall have provisions for a field installed filtered outside air intake.

D. Fan:
   1. Unit shall feature external static pressure settings from 0.14 to 0.60 in. WG.
   2. The indoor unit fan shall be an assembly with one or two Sirocco fan(s) direct driven by a single motor.
   3. The indoor fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings.
   4. The indoor fan shall consist of three (3) speeds, High, Mid, and Low plus the Auto-Fan function
   5. The indoor unit shall have a ducted air outlet system and ducted return air system.

E. Filter:
   1. Return filter box (rear or bottom placement) with 1” 30 % MERV 8 high-efficiency filter.
   2. Provide clean set of filters and one spare set of filters at substantial completion

F. Coil:
   1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
   2. The tubing shall have inner grooves for high efficiency heat exchange.
   3. All tube joints shall be brazed with phos-copper or silver alloy.
   4. The coils shall be pressure tested at the factory.
   5. A condensate pan and drain shall be provided under the coil.
   6. The condensate shall be gravity drained from the fan coil.
   7. Both refrigerant lines to the indoor unit shall be insulated.
G. Electrical:
1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

H. Controls: This unit shall use controls provided by unit manufacturer to perform functions necessary to operate the system.

2.5 CONTROLS

A. General:
1. The unit shall have controls provided with the unit by the manufacturer to perform input functions necessary to operate the system.
2. Computerized PID control shall be used to maintain room temperature within 1 F of setpoint.
3. The unit shall be equipped with a programmed drying mechanism that dehumidifies while inhibiting changes in room temperature.
4. The fan coil circuit board shall be wired to enable auxiliary heating when coil thermistor temperature drops below 104 degrees F in heating mode.

2.6 CONTROLLERS

A. Physical Characteristics: General: control system devices shall be a neutral color plastic material with a Liquid Crystal Display (LCD).

B. Electrical Characteristics:
1. General: From each circuit board to the controls, the electrical voltage shall be low voltage.
2. Wiring: Control wiring shall be installed in a daisy chain configuration from indoor unit to indoor unit then to the outdoor unit. Control wiring shall run from the indoor unit terminal block to the specific controller for that unit.
3. Wiring Size: The wire shall be a shielded, size AWG18-2.

2.7 INDIVIDUAL ZONE CONTROLLER – WIRED REMOTE CONTROLLER

A. The wired remote controller shall be able to control 1 group (maximum of 16 fan coil units) and shall be able to function as follows:
1. The controller shall have a self-diagnosis function that constantly monitors the system for malfunctions (total of 80 components).
2. The controller shall be able to immediately display fault location and condition.
3. An LCD digital display shall allow the temperature to be set in 1 degree Fahrenheit units.
4. The controller shall be equipped with a thermostat sensor in the remote controller making possible more comfortable room temperature control.
B. The wired remote controller shall have the following features:
   3. Scheduling: ON/OFF Timer
   4. Control Management: Field Setting Mode, Group Setting, Auto Re-start
   5. The controller shall also be able to switch an external dry contact via a 12 volt DC relay (field supplied).

2.8 INDIVIDUAL ZONE CONTROLLER – SIMPLIFIED WIRED REMOTE CONTROLLER

A. The simplified wired remote controller shall be able to control 1 group (maximum of 16 fan coil units).

B. The simplified wired remote controller shall have the following features:
   3. Scheduling: ON/OFF Timer
   4. Control Management: Field Setting Mode, Group Setting, Auto Re-start

2.9 SYSTEM REMOTE CONTROLLER

A. The controller shall control up to 64 units in 4 zones and shall be able to be used in conjunction with all room controller types. Provide as many system controllers as required to control the system. Collective and individual group commands are available with permit/prohibit individual remote controller function.. The system controller shall use the following connections for power and remote monitoring:
   1. L1: Power supply (60 Hz, 208-230 VAC)
   2. C1: Inter-unit control wiring (Low voltage)
   3. C3: Auxiliary
   4. C4: Ground for inter-unit control wiring
   5. A1: Input for turning ON air conditioners concurrently
   6. A2: Input for turning OFF air conditioners concurrently
   7. A3: Common input for turning air conditioners ON or OFF
   8. B1: On operation state indicator output
   10. B3: Common indicator output

2.10 WEB ENABLED INTELLIGENT CONTROLLER

A. This controller shall be wall mounted and hard wired, either directly to the VRF control system or via RS485 gateway. It will be manufactured in ABS plastic with an LCD
display and will be the manufacturer's standard color. The controller will be capable of individually controlling the following functions on 256 indoor fan coil units:
1. On/off.
2. Operating mode.
3. Set point.
4. Fan speed.
5. Louver position.
6. Timer settings.
7. Test run.

B. The controller shall also be capable of displaying the following information individually for 256 indoor fan coil units:
1. On/off.
2. Operating mode.
3. Set point.
4. Fan speed.
5. Louver position.
6. Timer settings.
7. Test run.
8. Fault diagnosis.

C. Each Intelligent controller unit can be accessed either locally or remotely via standard Internet Explorer IE6 or IE7 software. The Intelligent controller will be able to indicate system alarms via volt free contacts as well as providing control points for other D0 devices. Additionally, the intelligent controller shall be able to monitor individual tenant's usage of heating and cooling demands, report alarm and conditions to nominated email address, and enable remote alteration of systems set points to registered users.

2.11 GATEWAY:

A. Provide BACnet or LONworks Gateway to fully interface system function into building DDC control system. Manufacturer shall coordinate gateway requirements with control contractor prior to bid.

PART 3 EXECUTION

3.1 INSTALLATION

A. Installation, Operation and Maintenance manual shall be supplied with the unit.

B. Installing contractor shall install unit, including field installed components, in accordance with Installation, Operation and Maintenance manual instructions.

C. Start up and maintenance requirements shall be complied with to ensure safe and correct operation of the unit. Engage manufacturer or factory-authorized service representative to perform startup service. Manufacturer shall provide on-site startup
and commissioning assistance through job completion. Complete installation and startup checks according to manufacturer’s written instructions.

D. Unit manufacturer to provide services of factory trained personnel to verify operation of system installation and control hardware.

E. Provide all labor, refrigerant, and material required for a complete installation. Work to be performed shall be in accord with local codes, regulations, and OSHA standards.

F. Install all piping, fittings, and insulation to meet manufacturer’s requirements. Install units level and plumb. Evaporator-fan components shall be installed using manufacturer’s standard mounting devices securely fastened to building structure. Install and connect refrigerant tubing and fittings.

G. All lines from outdoor unit to BC controller / heat recovery box and all lines from BC controller to indoor fan coil unit shall be insulated. Refer to Section 230710 Insulation for specific requirements.

H. Installer shall supply isolation ball valves for zoned refrigerant isolation. Installer shall supply isolation ball valves with Schrader connection for isolating refrigerant charge and evacuation at each connected air handling unit and condensing unit. Isolation ball valves, with Schrader connection, are required for instances of air handling unit isolation for troubleshooting, repair or replacement without affecting the remainder of the system. Isolation ball valves with Schrader connection are also required at condensing unit connection to isolate unit for troubleshooting, repair or replacement and as required to provide partial capacity Heating/Cooling in the instance of a failure of one of the multiple outdoor unit (condensing unit) compressors.

I. Contractor shall install and pressure test piping system in accordance with manufactures instructions. Provide written documentation of all pressure tests.

3.2 OWNER TRAINING

A. The manufacturer that provides the VRV system for this project will include in his price the cost to have a “Factory Service Representative” provide onsite training for the VRV system to include, but not limited to:
   1. System rebooting.
   2. Identifying error codes.
   3. Resetting filter indicators.
   4. Basis system operation.
   5. Explanation of service indicators.
   6. How the manufacturer can support with system issues.

B. This training will be a minimum of:
   1. 8 hours during equipment startup.
   2. 8 hours at Substantial Completion.
   3. 8 hours and the end of the Manufacturer Warranty period.
C. Training shall be by a representative from the Factory. Training by local sales representative is not acceptable.

D. Prior to beginning of training, Manufacturer shall provide written material and outline of training for approval by Owner, Cx agent, and design team.

E. Contractor shall schedule training in advance with Owner.

END OF SECTION 237556
PART 1 GENERAL

1.1 WORK INCLUDED
   A. Provide UL listed electric heaters of the type and capacities specified on drawings.
   B. Heaters to have a five-year warranty.
   C. Heaters to be by Markel, Berko, Q-Mark, or approved equal.

PART 2 PRODUCTS

2.1 UNIT HEATERS
   A. Heaters to be Markel Series 5100 heavy-duty industrial service unit heaters for horizontal or vertical mounting.
   B. Enclosure to be heavy gauge steel with baked enamel finish.
   C. Heaters to be equipped with individually adjustable outlet louvers.
   D. Elements to be high mass, all steel finned tubular type.
   E. Motor to be equipped with permanently lubricated bearings and internal overload protection.
   F. Fan to be propeller type with fan speed not exceeding 1550 rpm.
   G. Heaters to be equipped with manual reset thermal cutouts to disconnect both heating elements and fan.
   H. Heaters to be designed for single point power connection, with elements, motor, and control circuits subdivided with factory installed and wired fuses.
   I. Thermostats to be line-voltage, unit mounted as scheduled on drawings, heavy-duty, tamperproof type. Manufacturer to furnish necessary contactors, relays, transformers, etc., for complete installation.
   J. Provide factory engineered bracket for attachment to wall or ceiling.
2.2 CEILING-MOUNTED HEATERS

A. Heaters to be Markel Series 3470 or 3480 commercial service, ceiling mounted, forced air heaters. See drawings for surface or recessed mounting requirements.

B. Enclosure to be constructed of heavy gauge steel finished with off-white baked enamel.

C. Elements to be high mass, all steel finned tubular type.

D. Motor to be equipped with permanently lubricated bearings and internal overload protection.

E. Fan to be propeller type with fan speed not exceeding 1550 rpm.

F. Heaters to be equipped with manual reset thermal cutouts to disconnect both heating elements and fan.

G. Heaters to be designed for single point power connection, with elements, motor, and control circuits subdivided with factory installed and wired fuses.

H. Thermostats to be wall-mounted, line-voltage, heavy-duty, tamperproof type. Manufacturer to furnish necessary contactors, relays, transformers, etc., for complete installation.

I. Provide plaster trim for heaters installed in "hard" ceilings.

PART 3 EXECUTION

3.1 INSTALLATION

A. Heaters to be installed in accordance with manufacturers’ published installation instructions.

END OF SECTION 238240
SECTION 260100
GENERAL PROVISIONS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 WORK INCLUDED

A. Switchboards.
B. Secondary power wiring and distribution system.
C. Fire alarm and smoke detection system.
D. Telephone system rough-in.
E. Security system.
F. Lighting control equipment.
G. Electrical control systems and interlock wiring.

1.2 RELATED WORK

A. Foundations and pads required for equipment furnished under this division of the specifications.
B. Field painting, except such painting as is required to maintain shop coat painting and factory finish painting.
C. Electrical control systems and interlock wiring as required by mechanical drawings, specifications or manufacturer's schematics.
D. Flashing of conduits into roofing and outside walls.
E. Heating, ventilating, and air conditioning equipment.
F. Plumbing equipment.

1.3 QUALITY ASSURANCE

A. Comply with applicable local, state and federal codes.
B. Comply with applicable requirements of recognized industry associations which promulgate standards for the various trades.
C. Employ only qualified journeymen for this work. Employ a competent qualified electrician to supervise the work.
1.4 STANDARDS

A. Perform work specified in Division 26 in accordance with standards listed below including amendments or revisions. When these specifications are more stringent, they take precedence. In case of conflict, obtain a decision from the Designer.

B. Reference Architectural for all applicable codes.

C. Should any work be construed as being contrary to or not conforming to aforementioned codes, such alleged confliction to be brought to attention of Architect in writing ten (10) days prior to bid date for review so that such point in question may be resolved. All work to be installed in strict conformity with applicable codes without additional cost to Owner.

D. Contractor to submit and/or file with proper authorities all necessary specifications and drawings as required by governing authorities.

1.5 SUBMITTALS

A. Within fifteen (15) days after contract has been awarded, Contractor to submit to Designer for review a complete list of materials, equipment, and accessories proposed for use, listing the item and manufacturer's name only.

B. Based upon aforementioned approved listing, Contractor to submit One (1) electronic PDF copy of COMPLETE BROCHURES AND SHOP DRAWINGS OF ALL MATERIALS, FIXTURES, AND EQUIPMENT that he proposes to use giving the names of manufacturers, trade name and specific catalog numbers.

C. Brochures to be submitted in time to allow fifteen (15) days from date of receipt in Engineer's office before final approval or disapproval is required to meet construction schedule. Submittals to bear Contractor's stamp of approval evidencing he has examined and checked same and information contained therein is in accordance with contract requirements, and any deviations to be clearly marked. Approval of shop drawings not to be construed as permitting departure from the contractual documents.

D. Above-mentioned brochures to be submitted and approved before any materials are ordered.

E. Brochures: Submit complete descriptions, illustrations, specification data, etc. of all materials, fittings, devices, fixtures, special systems, etc., including the following:
   1. Panelboards.
   2. Wiring devices and plates.
   3. Motor starters and contactors.
   4. Disconnect switches.
   5. Enclosed circuit breakers.
   6. Transformers.
   7. Lighting, including lamps.
F. Proposed items to be clearly indicated when other items are shown on same sheet. When proposing items other than those specified, brochures to contain both specified item sheets and proposed item sheets for ease of comparison. On request from Designer, samples shall be submitted and/or set up, as directed, for inspection and approval. Samples will be returned to Contractor.

G. Shop Drawings: Submit specific shop drawings for major materials including the following:
   1. Motor starters and contactors including custom wiring diagrams.
   2. Fire alarms and smoke detection systems, including point-to-point wiring diagrams.
   3. Dimensional layout of all electrical rooms, drawn to scale, with equipment location shown therein. Clearances to be in accordance with NEC and local codes.

1.6 OPERATING AND MAINTENANCE MANUALS

A. Prior to final acceptance of the project, furnish to Owner complete bound sets of operation and maintenance manuals of instructions for operation and maintenance of all pieces of equipment and systems provided under this division of specifications.

B. Manuals to also include all submittal data on all materials and equipment. Clearly indicate items provided on this project. A list giving name and address of nearest supply house carrying spare parts and name of Installation Contractor to be given to Owner.

C. Verbally instruct Owner's representatives. Contractor to obtain letter signed by the owner's representative indicating that the in-service training has been completed.

D. Three sets of the following data are required:
   1. Operating and maintenance instructions.
   2. Spare parts lists.
   3. Copies of approved submittal data.

E. Arrange each set of data in an orderly way, and bind each set in a separate 3-ring, hard-cover binder.

F. As soon as data accumulates, prepare one of the sets and deliver to the Owner's Representative, continuously updating this set as additional data is obtained.

G. At completion of work, submit two complete sets of data to the Owner's Representative for distribution to the proper parties.
1.7 DELIVERY AND STORAGE

A. Insofar as possible, deliver items in manufacturers’ original unopened packaging. Where this is not practical, cover items with protective materials, to keep them from being damaged. Use care in loading, transporting, unloading, and storage to keep items from being damaged.

B. Store items in a clean dry place and protect from damage.

C. All damaged painted surfaces of equipment to be touched up to match original paint.

1.8 RECORD DRAWINGS

A. Keep a set of blueline prints at the job site exclusively for recording deviations from the drawings.

B. Record locations and depths of buried and concealed conduits from fixed easily identifiable objects, such as building walls. Where conduits are concealed in walls, indicate distances off of building corners or other building features not likely to be disturbed by future alterations.

C. Mark deviations in colored pencils so that work of various systems can be easily identified.

D. When work is completed, record all deviations on clean sepia copies of drawings.

E. Submit three sepia copies of completed "record drawings" to Owner's Representative for distribution.

1.9 GENERAL

A. Modifications to system or equipment shall be coordinated by General Contractor. Any associated increase of cost of utility service/feeds proposed by General Contractor or Subcontractor shall be the responsibility of the Contractor.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. All materials and equipment used in carrying out these specifications to be American made unless approved otherwise by the Owner and to be new and have UL listing, or listing by other recognized testing laboratory when such listings are available. Specifications and drawings indicate name, type, and catalog numbers of materials and equipment to be used as "standards" shall not be construed as limiting competition. Contractor may at his option, use materials and equipment when, in the judgment of the Designer, they are equivalent to that specified.
PART 3 EXECUTION

3.1 COORDINATION

A. Intent:
   1. These sections of specifications and drawings form a complete set of documents for the electrical work of this project. Neither is complete without the other. Any item mentioned in one shall be as binding as though mentioned in both.
   2. The intent of these specifications and drawings is to form a guide for a complete electrical installation. Where an item is reasonably necessary for a complete system but not specifically mentioned, such as pull boxes, fittings, expansion fittings, support hangers, etc., provide same without additional cost to Owner.
   3. Electrical layouts indicated on drawings are diagrammatical only. Exact location of outlets to be governed by project conditions. The Designer reserves the right to make any reasonable changes (approximately 6 feet) in location of junction boxes, or equipment prior to roughing-in of such without additional cost to Owner.

B. Deviations:
   1. No deviations from specifications and drawings to be made without full knowledge and consent of Designer.
   2. Should Contractor find during progress of work that existing conditions make desirable a modification of the requirements of any particular item, report such item promptly to Designer for his decision and instructions.

C. Insofar as it is possible to determine in advance, leave proper chases and openings. Place all outlets, anchors, sleeves, and supports prior to pouring concrete or installation of masonry work. Should contractor neglect doing this, any cutting and/or patching required to be done is at this contractor's expense.

D. Visit site and be informed of conditions under which work must be performed. No subsequent allowance will be made because of error or failure to obtain necessary information to completely estimate and perform work involved.

E. Designer to be mediating authority in all design related deviations and disputes arising on the project.

F. Coordinate to assure that proper points of service transformer locations, voltage characteristics and capacity of service are in accordance with contract drawings.

3.2 CUTTING AND PATCHING

A. Repair or replace routine damage caused by cutting in performance of this contract.

B. Correct unnecessary damage caused due to installation of electrical work, brought about through carelessness or lack of coordination.
C. Holes cut through existing floor slabs to be core drilled with drill designed for this purpose. All openings, sleeves and holes in slabs between floors to be properly sealed, fire proofed and water proofed.

D. Repairs to be performed with materials which match existing materials and to be installed in accordance with appropriate sections of these specifications.

3.3 TRENCHING, EXCAVATION, BACKFILLING, AND REPAIRS

A. Provide trenching, excavation, and backfilling necessary for performance of electrical work.

B. Trenching and excavation to be unclassified. No extra will be paid in event that rock is encountered.

C. Backfilling to be carefully done using only clean earth thoroughly tamped and compacted below and above embedded items.

3.4 FOUNDATIONS AND PADS

A. Provide foundations and pads required for equipment provided under this division of specifications. Coordinate proper size and location of foundations, pads, anchor bolts, and other items to be built into structure.

B. Concrete to be in accordance with concrete division of these specifications.

3.5 TESTS

A. On completion of work, installation to be entirely free from grounds, short circuits, and open circuits. Perform a thorough operational test in presence of Owner or his representative. Balance all circuits so that feeders to panels be not more than 10% out of balance between phases with all available load energized and operating. Furnish all labor, materials and instruments for above tests.

B. Furnish Owner, as a part of closing file, a copy of such tests including identification of each circuit and readings recorded. Test information to be furnished to Owner includes ampere readings of all panels and major circuit breakers, insulation resistance reading of motors and transformers.

C. Prior to final observation and acceptance, test, leave in satisfactory operating condition all electrical systems and equipment including but not limited to the following:
   1. Electrical distribution system.
   2. Ground fault protection system.
   3. Emergency power generation system.
   4. Transformers.
   5. Fire alarm and smoke detection system.
   6. Electric motors for all equipment.
8. Any alarm system.
9. CCTV system.

3.6 INSPECTION FEES AND PERMITS

A. Obtain and pay for all necessary permits and inspection fees required for electrical installation.

3.7 IDENTIFICATION OF EQUIPMENT

A. Properly identify all starters, contactors, relays, safety switches and panels with permanently attached black (normal power) or red (essential systems) phenolic plates with 1/4" white engraved lettering on the face of each attached, with two sheet metal screws. Starters and relays connected by the electrical tradesman to be identified by him whether furnished by him or others.

3.8 TEMPORARY LIGHTS AND POWER

A. Provide a temporary electrical lighting and power distribution system of adequate size to properly serve the following requirements, including adequate feeder sizes to prevent excessive voltage drop. Temporary work to be installed in a neat and safe manner in accordance with the National Electrical Code, Article 590, and as required by OSHA or applicable local safety codes.

B. Provide one duplex power outlet for every 1,500 square feet of floor area, evenly distributed throughout the building. Power outlets to be 20 amp, single phase located as directed by the contractor.

C. Check with contractor prior to installation to determine if any lighting or power outlets over the maximum quantity noted above are required.

D. Provide service and panelboards required for above lighting and power outlets.

E. Contractor to maintain the existing lights and power during normal regular hours as directed by Owner. Any interruption of power must be approved by and coordinated with Owner's representative.

3.9 DEMOLITION

A. Contractor shall visit the site before submitting a bid to acquaint himself with existing conditions.

B. Work in existing buildings shall be scheduled well in advance with the Owner. Work shall be performed at such times and under such conditions as suit the convenience of the Owner. Plan the work to minimize disruption of formal operations.

C. In renovated areas, remove wiring devices, fixtures, components, electrical equipment, conductors, boxes, and conduits not required to remain in service when this project is complete.
D. Remove existing conduit and wire from areas to be remodeled, back to panelboard, cabinet or junction box.

E. Where a circuit is interrupted by removal of a device or fixture from that circuit, the contractor shall install wire, conduit, etc., as required to restore service to the remaining devices and fixtures on that circuit.

F. Lighting fixtures, wiring devices, panelboards, and conductors removed shall be offered to the Owner. If he chooses to retain these items or a part of these items, turn those chosen over to him. Items rejected by the Owner shall be removed from the project site by the contractor.

3.10 OBSERVATIONS

A. When field observation services are a part of the project scope, Engineer's office will provide periodic observation of the progress of work specified herein. Purpose of the observation is to ensure compliance of Contractor's work with specifications and drawings. Engineer's office will also observe tests required of Contractor as called for in other sections of specifications.

B. Specifications and drawings represent work to be done in view of total project requirements. Final location of conduits, fixtures, panels, switchboards, etc., to eliminate possible conflict with other trades is responsibility of Contractor. Contractor to provide all supervision required for his personnel to ensure that installation is made in accordance with specifications and drawings and all safety rules and regulations are observed. In event of conflicts of work on project with other trades, Contractor to make every reasonable effort to resolve conflict through meetings and discussions with other parties involved, by preparation of drawings or other appropriate action. Only after this has been done shall the Engineer's assistance be requested.

C. When Engineer is requested to visit project to aid in resolution of conflicts or for witnessing tests, he shall be given a minimum of 48 hours' notice prior to time his presence is required at job site.

D. Cost of Engineer's time for general observation or test observance as described herein is to be borne by Engineer except in those cases where Engineer has been requested to visit project and upon visiting finds Contractor has caused Engineer an unnecessary visit. It shall be deemed an unnecessary visit in the following circumstances.

1. Due to lack of supervision on Contractor's part.
2. Test is not ready for observation.
3. Engineer is placed in role of determining reason system or equipment is not operating properly, only to find that Contractor has not fulfilled his responsibility in troubleshooting, etc.
4. Contractor requests a trip to check off final punch list items and it is found that no attempt has been made by Contractor to correct previous punch list items.
5. Contractor will be billed for Engineer's time for making unnecessary visit at the rate of $400 per day plus mileage and living expenses.
3.11 WARRANTY-GUARANTEE

A. Designer reserves right to accept or reject any part of installation which does not successfully meet requirements as set out in these specifications.

B. Contractor shall and hereby does guarantee all work installed under this division shall be free from defects in workmanship and materials for a period of one year from date of final acceptance, whichever is earliest. The above parties further agree that they will repair and replace any defective material or workmanship which becomes defective within the terms of this warranty-guarantee.

END OF SECTION 260100
SECTION 260519
CONDUCTORS - 600 VOLT AND BELOW

PART 1 GENERAL

1.1 WORK INCLUDED

A. Provide a complete system of conductors for lighting, power, and controls throughout building.

B. Refer to drawings for sizes of conductors.

PART 2 PRODUCTS

2.1 CONDUCTORS - POWER AND LIGHTING

A. Provide 98% conductivity copper conductors with 600-volt insulation.

B. Interior conductors shall be Type THHN-2/THWN-2 insulation.

C. 600-volt insulation for conductors installed in underground raceways shall have XLP (cross-linked polyethylene) insulation, Type XHHW-2.

D. For feeder and branch circuit conductors No. 12 AWG and No. 10 AWG, provide solid type.

E. For all control and motor circuits, and all conductors No. 8 AWG and larger, provide stranded type.

F. Conductors shall be manufactured by Triangle, Phelps Dodge, Southwire, or approved substitute.

G. Provide white or gray colored neutral conductors; provide black or color coded phase conductors.

H. Provide No. 14 AWG stranded type THHN fixture conductors, for conductors entering fixtures and in stems of pendant fixtures.

I. Provide type THHN stranded conductors, 90 degrees C for conductors running through continuous rows of fluorescent fixtures.
PART 3 EXECUTION

3.1 INSTALLATION

A. Install pull boxes in circuits or feeders over 100’ long.

B. All conductors shall be continuous from origin to panel or equipment termination without splices where possible. Where splices and taps are necessary or are required, they shall be made in splice boxes with suitable connectors.

C. Make all splices or connections only at outlet, pull or junction boxes.

D. Use pulling compound to pull conductors except conductors from isolation transformers.

E. Install instrument and data connection conductor in separate raceways from all other conductors. Separate control wiring from power wiring in separate raceways. Separation distances shall be as specified by control system manufacturer or as listed in IEEE Standard 518, whichever is greater.

F. Bend radius on conductors shall be less than the limitations listed by the cable manufacturer.

G. Deliver all conductors to job site new and in original wrapping, package or reel.

H. All conductors and connections shall test free of grounds, shorts, and opens.

I. For 20-amp, 120-volt branch circuits, provide No. 10 wire in lieu of No. 12 wire for any branch circuit in excess of 90 linear feet to prevent excessive voltage drop. Where branch circuit exceeds 175 linear feet, use No. 8 wire.

J. Use Ideal wing nuts, Scotchlok Type Y, R, G, or B, or approved equivalent connectors for fixture connections at outlet boxes.

K. Make feeder taps and joints with OZ type T, PT, PM or PTS, or approved equivalent clamp connectors as manufactured by Kupler, or with approved compression sleeves. Wrap connectors with No. 10 electro-seal or approved equivalent plastic filler and vinyl tape.

L. Leave a minimum of 8” slack wire in every outlet box whether it be in use or left for future use.
M. Color code conductors as follows:

<table>
<thead>
<tr>
<th>CONDUCTOR COLOR CODE</th>
<th>120/208 Volt</th>
<th>277/480 Volt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase A</td>
<td>Black</td>
<td>Brown</td>
</tr>
<tr>
<td>Phase B</td>
<td>Red</td>
<td>Orange</td>
</tr>
<tr>
<td>Phase C</td>
<td>Blue</td>
<td>Yellow</td>
</tr>
<tr>
<td>Neutral</td>
<td>White</td>
<td>Gray</td>
</tr>
<tr>
<td>Ground</td>
<td>Green</td>
<td>Green</td>
</tr>
</tbody>
</table>

N. If the above conflicts with existing color coding, match existing.

O. Use factory color coded conductors where commercially available. If not, use black wire and band with color tape.

END OF SECTION 260519
SECTION 260526
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 WORK INCLUDED

A. The entire system of raceways and equipment to be grounded in accordance with Article No. 250 of latest edition of National Electrical Code and any local regulation or governmental governing authority.

PART 2 PRODUCTS

2.1 GROUND CLAMPS

A. OZ Electrical Manufacturing Company, Steel City, Appleton, or approved substitute.

B. Feeder circuits to panels, motor control centers, etc., shall have a separate green grounding conductor in conduit sized in accordance with Table 250.122 of N.E.C.

C. All branch circuits shall have a separate green grounding conductor installed in same conduit as phase and neutral conductor from panel ground bus to device. The grounding conductor shall be sized in accordance with Table 250.122 of N.E.C.

D. Flexible conduit will not be approved as achieving continuity of ground. All flexible conduit shall have a jumper wire sized to ampacity of branch breaker and shall be connected to conduit system on both ends; this applies to fixtures, motors, controls, etc.

PART 3 EXECUTION

3.1 INSTALLATION

A. Effectively bond all grounding conductors to grounding electrodes, equipment enclosures and ground busses.

B. Provide a shunt path around main water meter by bonding around both sides of meter to assure continuity.

C. Locate all grounding attachments away from areas subject to physical damage. Provide protective covering as required.
D. Clean all non-conductive surfaces on equipment to be grounded, to assure good electrical continuity.

END OF SECTION 260526
PART 1 GENERAL

1.1 WORK INCLUDED

A. Provide a system of supporting devices and hangers to ensure secure support or bracing for conduit, electrical equipment, including safety switches, fixtures, panelboards, outlet boxes, junction boxes, cabinets, etc.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Provide appropriate supporting devices and hangers as manufactured by Erico Products, Inc., Steel City, Rayco, or approved substitute:
1. Vertical flange clamps (beam clamps).
2. "Z" purlin clips.
3. Conduit clips.
4. Universal clamps (Beam clamps).
5. Beam clamps (set screw type).
6. Combination push-in conduit clips.
7. Combination conduit hanger clamps.
8. Flexible conduit clips.
9. Special combination conduit clips.
10. One-hole steel straps.
11. Minerallac conduit hangers.

PART 3 EXECUTION

3.1 INSTALLATION

A. Secure conduits to within 3’ of each outlet box, junction box, cabinet, fitting, etc., and at intervals not to exceed ten feet (10’) for EMT and IMC conduit and in accordance with Table 344.30 (B) (2) for Rigid Steel conduit.

B. Install clamps secured to structure for feeder and other conduits routed against the structure. Use drop rods and hangers or racks to support conduits run apart from the structure.

C. Furnish and install suitable angle iron, channel iron or steel metal framing with accessories to support or brace electrical equipment including safety switches, fixtures, panelboards, outlet boxes, etc.
D. Paint all supporting metal not otherwise protected, with rust inhibiting primer and then with a finish coat if appropriate to match the surrounding metal surfaces. (Prepainted or galvanized support material is not required to be painted or repainted.)

E. Use of chains, perforated iron, bailing wire, or tie wire for supporting conduit runs will not be permitted.

F. For support of low voltage wiring not required to be in conduit, Contractor shall bundle cables together in a neat manner using approved nylon tie wraps. Bundled cables shall be supported with "J" hooks on telephone type bridle rings, a minimum of 6 feet on centers. Contractor shall clearly identify all differing types of cables being run and tag them with tape tags reading "telephone", "data", etc., for the appropriate system cables. Identification tape shall be provided at minimum intervals of 25 feet on center and within each building space.

END OF SECTION 260529
SECTION 260534
RACEWAYS AND CONDUIT SYSTEMS

PART 1 GENERAL

1.1 WORK INCLUDED
   A. Provide a complete conduit system with associated couplings, connectors, and fittings.
   B. Conduits shall be mechanically and electrically continuous from outlet to outlet and from outlets to cabinets, pull or junction boxes.

1.2 SUBMITTALS
   A. Submittal for products furnished under this section is not required.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS
   A. EMT conduit shall be hot-dip galvanized, or electrogalvanized steel by Allied, Wheatland Tube, Republic Conduit, Western Tube, or approved substitute.
   B. EMT conduit connectors from 1/2” to 2” trade sizes shall use set screw type. EMT conduit connectors from 2-1/2” to 4” trade sizes shall use two set screw type.
   C. Weatherproof hub shall be complete with sealing "O" ring or sealing locknuts.
   D. Provide polyvinyl chloride (PVC) conduit, Type 40, and associated couplings, connectors, and fittings. PVC conduit shall be UL listed and 90 degrees C UL rated.

2.2 ELECTRICAL METALLIC TUBING (EMT)
   A. Use Electric Metallic Tubing (EMT) for:
      1. Branch circuits installed overhead, both exposed and concealed, installed more than 6 feet above finished floor.
      2. Branch circuits originating from isolated panels (O.R., Cystoscopy, or Delivery).
      3. Panelboard feeders.

2.3 POLYVINYL CHLORIDE (PVC)
   A. Use PVC for:
      1. Service entrance conduits for power encased in concrete.
      2. Service entrance conduits for telephone.
4. Exterior underground branch circuits.

B. PVC conduit shall not be used for feeders or branch circuits inside the building.

2.4 FLEXIBLE METAL CONDUIT

A. Provide a flexible metal conduit system for the termination points at equipment that may possibly vibrate such as motors, welders, etc. The length shall not exceed 6 feet.

B. Conduit shall be electrically continuous from outlet or conduit end to the utilization equipment.

C. The total length of flexible conduit in any circuit shall not exceed 6 feet.

D. Where exposed to continuous or intermittent moisture, conduit shall be liquid tight flexible type, U.L. Type EF.

PART 3 EXECUTION

3.1 INSTALLATION

A. Minimum size of conduits shall be 1/2 inch.

B. Conduit joints shall be cut square, threaded, reamed smooth, and drawn up tight so conduit ends will butt in couplings, connectors, and fittings.

C. Make bends or offsets with standard ells or field bends with an approved bender.

D. Run conduits concealed in floor slabs, below slabs, or in walls in direct line with long sweep bends or offsets. Run exposed conduits and conduits run above lay-in ceilings parallel to and at right angles to building lines. Group multiple conduit runs in banks.

E. Secure conduits to all boxes and cabinets with two locknuts and bushings so system will be electrically continuous from service to all outlets.

F. Cap ends of conduits to prevent entrance of water and other foreign material during construction.

G. Complete conduit systems before pulling conductors.

H. Conduits shall be divided according to voltage and amperage service level. Conduits of different voltage levels shall be physically separated by the following distances unless otherwise specified on the drawings by the electrical engineer or control system supplier.

1. Level 1 conduits shall contain low level input/output signal conductors including RTD cables, thermocouple cables, and 4-20 mA d.c. cables from field transmitters.
2. Level 2 conduits shall contain all conductors for 24 volts d.c. power and signal.
3. Level 3 conduits shall contain all conductors for 120 volt a.c. power to the PLC control cabinets, motor control circuits, field devices requiring 120-volt power, etc.
4. Level 4 conduits shall contain all conductors for 120 volts d.c. control power greater than 3 amps, all 120 volts a.c. power greater than 20 amps, and all power circuits with voltage ratings higher than 120 volts a.c. (277, 480, 4160, 13,200 volts etc.). Examples include 480-volt motor feeds, 5-kV feeders, and 120-volt lighting circuit and input/output devices such as limit switches and solenoid valves.
5. Conduits shall be physically separated from each other by the following distances:

<table>
<thead>
<tr>
<th>SPACING REQUIREMENTS (IN INCHES) FOR METALLIC CONDUITS</th>
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<tr>
<td>From Level</td>
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<tr>
<td>Level 1</td>
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<tr>
<td>Level 2</td>
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<td>Level 3</td>
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6. Levels 1, 2, and 3 conductors shall additionally be routed away from sources of high voltage or RF radiation such as switchgear, transformers, radio transmitters, and repeaters. Minimum separation from these sources of interference shall be 5 feet.
7. Data highway communications cable are generally considered Level 1 conductors; however, special requirements apply for routing to assure a low noise environment. Refer to electrical drawings and controls supplier requirements for special considerations before routing these conduits.

I. Where conduits of different levels must cross, the minimum separations shall be maintained, and they shall cross at right angles.
J. Provide cable supports in conduits rising vertically in accordance with the National Electrical Code, Article 300-19.
K. Provide nylon pull cord in all empty conduits. Steel wire not acceptable as pull wire.
L. Conduits which pass through floor slabs (except ground floor) shall be sealed with concrete grout. Seal around conduits or other wiring materials passing through partitions, which extend to the underside of the slab above, and those passing through smoke partitions and fire-rated walls. Refer to appropriate details on architectural and mechanical drawings.
M. Conduits which enter crawl space, tunnels, and basements from outside the building shall be grouted-in to prevent entry of gases, vapors, insects, or rodents to these spaces from street mains.
N. Conduit not serving elevator equipment shall not be permitted to pass through elevator shafts or elevator equipment rooms.
O. In areas where enclosed and gasketed fixtures and weatherproof devices are specified, where rigid conduit enters a sheet metal enclosure, junction box and outlet box, and not terminated in a threaded hub, a steel, or malleable iron nylon insulated hub, complete with recessed sealing "O" ring or sealing locknut shall be used.

P. Where conduits stub up in conduit space beneath switchgear and do not connect directly to equipment enclosures, use malleable iron nylon insulated ground bushing with a lay-in lug design complete with bonding screw, Raco 1212-1296.

Q. Provide seal-off fitting in all conduits entering hazardous areas and any conduits entering a cold temperature area such as freezers and dry refrigerators.

R. In concrete slabs, block up conduit from forms and securely fasten in place. All conduits in slabs shall have a minimum of 1-1/2 inches concrete coverage above and below.

S. Encase in 4 inches of 1:2:4 mix concrete on all sides all feeder conduits laid below ground outside building foundation line.

T. Where conduits running overhead pass through building expansion joints they shall be connected by flexible metal conduit of same size with sufficient slack to allow conduits on either side of expansion joint to move a minimum of 3 inches in any direction. Provide supports as required on each side of expansion joint, all in accordance with seismic requirements of specific area.

U. Conduits for feeders and branch circuits shall be terminated directly into panelboard enclosure without the use of pull boxes, junction boxes, wireways, or auxiliary gutters, unless the panelboard enclosure does not provide sufficient surface area for all conduits. Where such cases exist, the contractor shall notify the Designer. In no case will splices in such boxes, wireways, etc., be permitted.

V. Failure to route conduit through building without interfering with other equipment and construction shall not constitute a reason for an extra charge. Equipment, conduit, and fixtures shall fit into available spaces in building and shall not be introduced into building at such times and manner as to cause damage to structure. Equipment requiring servicing shall be readily accessible.

W. No conduit shall be installed in elevated slabs.

3.2 EMT

A. Do not use electric metallic tubing in cinder concrete or cinder fill where subject to permanent moisture unless protected on all sides by a layer of noncinder concrete at least 2 inches thick or unless the EMT is at least 18 inches under the fill. Use of setscrew fitting is not acceptable in concrete or in fill under slab.

3.3 PVC

A. Use threaded fittings for all connectors and adapters.
B. Provide code sized ground conductors in all power conduit runs.

C. Provide 1/4-inch nylon pull rope in all primary power and incoming telephone service entrance conduits.

D. Encase all PVC conduit in reinforced concrete with a minimum of 4-inch encasement on all sides except exterior branch circuits.

E. No PVC shall emerge from the ground or the concrete slab or encasement. PVC shall convert to galvanized rigid metal prior to its emergence.

F. Make bends with standard ells or with an approved heat bender.

3.4 FLEXIBLE METAL CONDUIT

A. Flexible metal conduits shall be 1/2 inch minimum size.

B. Where fittings for liquidtight flexible conduit are brought into an enclosure with a knock-out, a gasket assembly, consisting of one piece "O" ring, with Buna-N sealing material, Raco Series 3500, shall be installed on outside of box. Fittings shall be made of either steel or malleable iron only, and shall have insulated throats or insulated bushings.

C. In dry locations, where final connections to motors and other equipment may be made with flexible metal conduit, fittings shall be of steel or malleable iron only with insulated throats or insulated bushings, and shall be of wedge and screw type having an angular wedge fitting between convolutions of conduit.

D. An additional copper ground wire shall be installed inside of flexible conduit and bonded at each end to assure continuity of ground to lighting fixtures, controls, and other utilization equipment.

E. All recessed lighting fixtures shall be connected with flexible metallic conduit from outlet box to fixture. Rigid conduit connections to lighting fixtures are not acceptable.

F. Install liquidtight flexible conduit in such a manner as to prevent liquids from running on the surface toward fittings.

G. Allow sufficient slack conduit to reduce the effect of vibration.

END OF SECTION 260534
SECTION 260537
OUTLET BOXES

PART 1 GENERAL

1.1 WORK INCLUDED

A. Provide each fixture, switch, receptacle, communication devices, and other wiring devices with a galvanized outlet box of appropriate size and depth for its particular location and use unless indicated otherwise.

1.2 SUBMITTALS

A. Submittals are not required for items furnished under this section.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Outlets and junction boxes shall be Steel City or approved substitute.

B. Provide 4" square x 1-1/2" deep boxes for switches and receptacles in drywall partitions. Use square cut plaster rings of proper gauge and depth.

C. Provide 4" x 1-1/2" octagonal boxes for ceiling outlets. For increased cubic capacity provide 4" x 2-1/8" octagonal, 4" x 1-1/2" square or 4" x 2-1/8" square boxes for ceiling outlets.

D. Provide 4" x 3-1/2" octagonal concrete rings with removable back plates and fixture studs for ceiling outlets in prestressed or reinforced concrete slabs.

E. Provide 2-1/2" x 3-3/4" one gang masonry boxes for switches and receptacles installed in concrete block walls not plastered. For increased cubic capacity provide 3-1/2" x 3-3/4" one gang masonry boxes. Where more than two conduits enter the box from one direction, provide 4" square boxes with square cut device covers not less than 1" deep specifically designed for this purpose. Use round edge plaster rings only if the block walls are to be plastered. Use sectional or gangable type outlet boxes only in dry wall construction.

F. For all systems boxes, provide 4-11/16" square outlet boxes with square cut device corners for block walls or round edge plaster rings for plastered walls. Single gang device boxes are not acceptable.
G. Permanent barriers shall be furnished in multi-gang boxes if the voltage between adjacent wiring devices exceeds 300 volts.

H. Provide galvanized malleable iron fittings with threaded hubs for screw connections and with the proper type covers for switches and receptacles served by exposed conduit. Use pressed steel outlet only for ceiling fixture outlets.

I. Provide galvanized malleable iron condulets with threaded hubs and covers and with proper configurations for all changes of direction of exposed conduits. Standard conduit ells may be used if they do not interfere or damage or mar the appearance of the installation.

J. Provide rectangular boxes for floor outlets. Boxes to be 2-gang or 3-gang, fully adjustable before and after concrete pour, Steel City No. 642-643. Cover to be Steel City No. P64-D4/P6DS, aluminum, with duplex screw cover for duplex receptacle. Carpet flange to be lexan type. Fittings to be Steel City No. SFH50, satin aluminum for high tension and Steel City No. SFH50-TEL, satin aluminum for low tension. For boxes in elevated slabs less than four inches thick, use Steel City 642 and 643-SC.

PART 3 EXECUTION

3.1 INSTALLATION

A. Locate boxes to prevent moisture from entering or accumulating within them.

B. Use boxes of sufficient cubic capacity to accommodate the number of conductors to be installed. See Article #370 of the latest edition of the National Electrical Code.

C. Effectively close unused openings in boxes with metal plugs or plates.

D. Set recessed boxes so that front edges are flush with finished surfaces.

E. Secure boxes to surfaces upon which they are mounted or embed boxes in concrete or masonry. Support boxes from structural members with approved braces.

F. Install blank device plates on outlet boxes left for future use.

G. Provide bushings in holes through which cords or conductors pass.

H. Install boxes so that the covers will be accessible at all times.

I. Outlet boxes in walls shall not be mounted back to back. Where drawings show outlets on both sides of the same wall, the boxes shall be staggered sideways and connected with short nipples to prevent passage of sound. Where outlets are mounted on both sides of same fire wall they are to be staggered a minimum of 24 inches to maintain the ratings of the wall.
J. Where required to hang a specified fixture, provide a fixture stud of the no-bolt, self-locking type on ceiling outlets.

END OF SECTION 260537
PART 1 GENERAL

1.1 WORK INCLUDED

A. Provide pull and junction boxes of appropriate size and depth or as indicated on the drawings and as specified hereinafter.

1.2 SUBMITTALS

A. Submittals of products furnished under this section are not required.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS/MATERIALS

A. Pull and junction boxes shall be by Hoffman or approved substitute.

B. For interior work, provide galvanized sheet metal boxes of code thickness with lapped and welded joints, 3/4 inch flanges, screw covers, etc.

C. For exterior work, provide galvanized sheet metal boxes of code thickness with lapped and welded joints, 3/4 inch flanges, bolted covers with full gaskets forming a completely water-tight assembly, equal to Hoffman, Concept Series.

D. For exterior work in graded areas outside the building, provide heavy duty sidewalk junction boxes externally flanged for flush mounting. Covers to be fully gasketed, watertight and secured with plated screws or bolts. Crouse-Hinds Type WJB or approved substitute. See detail on drawings for size.

PART 3 EXECUTION

3.1 INSTALLATION

A. Provide junction boxes as shown on drawings and otherwise where required, sized according to number of conductors in box or type of service to be provided. Minimum junction box size 4 inches square and 2-1/8 inches deep. Provide screw covers for junction boxes.

B. Use minimum 16 gauge steel for pull boxes and provide with screw cover.

C. Install boxes in conduit runs wherever necessary to avoid long runs or excessive bends. Do not exceed 100 foot runs, or three 90 degree bends, without pull boxes.
D. Rigidly secure boxes to walls or ceilings. Use of conduit as a support is not acceptable.

E. Install boxes in accessible locations. Size boxes in accordance with Articles No. 312 and No. 314 of the latest edition of the National Electrical Code.

F. Install boxes so that the covers will be accessible at all times.

G. Do not install pull or junction boxes for joint use of line voltage and signal or low voltage controls unless all conductors are insulated for the highest voltage being used in the same box. Emergency system and normal system circuits shall not be routed through a common pull or junction box.

END OF SECTION 260538
SECTION 262200
DRY TYPE TRANSFORMERS

PART 1 GENERAL

1.1 WORK INCLUDED

A. All work specified in this section shall comply with the provisions of Section 260100.

B. Provide dry type transformer as shown on riser diagram.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Transformers shall be as manufactured by Square D, G.E., Cutler-Hammer, or approved substitute.

2.2 EQUIPMENT REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Comply with NFPA 70: Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Transformers Rated 15 kVA and Larger:
   1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
   2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.

D. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.
   1. One leg per phase.
   2. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.
   3. Grounded to enclosure.

E. Coils: Continuous windings without splices except for taps.
   1. Coil Material: Copper.
   2. Internal Coil Connections: Brazed or pressure type.
   3. Terminal Connections: Bolted.

F. Taps for Transformers 15 kVA AND Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.
G. Insulation Class, Smaller than 30 kVA: 180 degrees C, UL-component-recognized insulation system with a maximum of 115 degrees C rise above 40 degrees C ambient temperature.

H. Insulation Class, 30 kVA and Larger: 220 degrees C, UL-component-recognized insulation system with a maximum of 150 degrees C rise above 40 degrees C ambient temperature.

I. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.

J. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
   1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding the indicated insulation class in a 40 degrees C maximum ambient and a 24-hour average ambient of 30 degrees C.
   2. Indicate value of K-factor on transformer nameplate.
   3. Unit shall comply with requirements of DOE 2016 efficiency levels when tested according to NEMA TP 2 with a K-factor equal to one.

K. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
   1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
   2. Include special terminal for grounding the shield.

L. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.

M. Sound levels shall not exceed the following ranges:
   1. 0-9KVA: 40db
   2. 10-50KVA: 45db
   3. 51-150KVA: 50db
   4. 151-300KVA: 55db
   5. 301-500KVA: 60db
   6. 501-700KVA: 62db

N. Immediately prior to initial varnish impregnation entire core and coil assembly to be thoroughly dried in a preheat cycle, and then thoroughly baked to ensure that all volatiles have been driven off in process. Core and coil assembly to be internally isolated from enclosed through use of an effective vibration dampening system.

PART 3 EXECUTION

3.1 INSTALLATION

A. Provide flexible conduit to and from transformer.
B. Install transformers in accordance with manufacturers’ recommendations.

C. Provide trapeze type hangers for transformers supported from the structure or mount on the floor as shown on the drawings. Floor mounted transformers shall be securely anchored to a 4” reinforced concrete housekeeping pad. Provide working clearances as required by NEC.

D. Provide both primary and secondary protection by use of fuses or circuit breakers as shown on drawings.

END OF SECTION 262200
PART 1 GENERAL

1.1 WORK INCLUDED

A. Provide circuit breaker type panelboards as indicated on drawings and as specified in this section.
B. Refer to drawings for numbers of branch circuits, their ratings, number of poles, arrangements, etc.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS/EQUIPMENT

A. Provide panelboards by Square D, G.E., Siemens, Cutler-Hammer, or approved substitute. Square D type designations are used to indicate type and quality of panelboards.
B. Lighting panelboards for 120/208-volts, 3-phase, 4-wire service shall be Square D type NQOD.
C. Lighting panelboards for 277/480-volts, 3-phase, 4-wire service shall be Square D type NF.
D. Power panelboards for 120/208-volt, and 480/277-volt, 3-phase, 4-wire service shall be Square D I-Line distribution type.
E. Lighting and power panelboards and their associated circuit breakers shall be furnished with a short-circuit current rating greater than the available fault current shown on the panel schedules.
F. Series rated panelboards are not acceptable.
G. Provide panelboards of circuit breaker, dead-front safety type, UL labeled and meeting all applicable requirements of the National Electrical Manufacturers Association.
H. Provide panelboards with lugs (both main lugs and branch circuit lugs) suitable and UL approved for aluminum and copper 75 degree C rated conductors.
I. Provide shunt trip and GFI breakers where indicated on panel schedule.
J. Provide electrically isolated neutral bars.
K. Provide separate ground bars complete with lugs or connectors on bar.

L. Provide panelboards with sequence phased bus bars or distributed phase bussing for: 3-phase, 4-wire, 277/480-volts wye and 120/208-volts wye.

M. Provide panel doors equipped with chrome-plated locks and catches, all keyed alike. Provide two keys for each lock. Provide fronts with adjustable indicating trim clamps.

N. Provide thermal magnetic circuit breakers which are fully rated and temperature rated for a 40 degree C ambient. Breakers shall be quick-make, quick-break type with trip indication shown by handle position other than ON or OFF and with a common trip on all multi-pole breakers.

O. Where specific panelboard types, breaker types, or adjustable breaker devices are shown on the drawings, and the contract elects to use another manufacturer or type, contractor will be responsible for additional cost incurred by the designer for evaluation of breaker coordination.

PART 3 EXECUTION

3.1 INSTALLATION

A. Ground separate ground bars to panel boxes and to the main service entrance ground bus with a code-sized grounding conductor installed in the same conduit as the phase and neutral conductors.

B. Install all circuits which use a common neutral in accordance with the latest edition of the National Electrical Code, Article Nos. 210-4, 210-5, 215-4, and 220-4d. Balance all circuits to achieve not greater than 10% unbalanced neutral current in panel feeders.

C. Provide six circuit breaker handle lock-on devices for each lighting panelboard for installation by the contractor on circuits as directed by the Owner to prevent unauthorized personnel from turning off circuits to controls, unit heaters, clocks, night lights, etc. Turn the spare lock-on devices over to the Owner for his use.

D. Provide typed directory cards mounted under plastic on the doors of all panelboards. The directories shall indicate the type of devices being served, including the space number or space names in which the devices or fixtures are located.

E. Provide engraved Bakelite nameplates for all the circuit breakers in use on power panelboards. Indicate the device, panel, or motor being served with 1/4" high letters. Provide nameplates without engraving for the spare breakers and/or spaces. Secure all nameplates to the panelboard trim with two roundhead sheet metal screws.

F. Provide engraved Bakelite nameplates on the visible face of all lighting and power panels indicating the panel and emergency system branch designation in 3/8" letters. Secure the nameplates with a minimum of two round-head sheet metal screws.
Normal power nameplates shall be black and emergency power nameplates shall be red.

G. Provide 7 sets of final as-built drawings for the panels after delivery of the panels for distribution by the Owner.

END OF SECTION 262416
SECTION 262726
WIRING DEVICES

PART 1 GENERAL

1.1 WORK INCLUDED

A. Provide switches, receptacles, device plates, and other wiring devices as indicated on drawings.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers include Leviton, Hubbell, Eagle, Arrowhart, Pass and Seymour, and Bryant. Leviton numbers are used for clarity.

2.2 SWITCHES

A. 20-Amp, 120/277 VAC:
1. Single pole: Leviton No. 1221-2W.
2. Three-way: Leviton No. 1223-2W
3. Single pole, weatherproof: Leviton No. 1221-2W with Steel City No. SW1-C weatherproof plate.
4. Single pole with pilot light (120 VAC): Leviton No. 1221-PLC.
5. Momentary contact switch: Leviton No. 1257.

B. Dimmers shall be universal (LED/CFL/MLV/Incandescent) slide dimmers equal to Leviton DSM10-1LZ.

2.3 RECEPTACLES

A. 20-Amp, 125-VAC, NEMA 5-20R:
1. Duplex type: Leviton No. 5362-W (white).
2. Ground fault circuit interrupter: Leviton No. MGFN2-W (white).
3. Tamper resistant type: Leviton 5362-SGW (white).
4. Duplex isolated ground type: Leviton 5362-IGW (white).
5. Weatherproof "In Use", extra-duty type cover: Leviton 5980-UCL.

2.4 MISCELLANEOUS DEVICES

A. Twist lock receptacle: Hubbell No. 23000-HG series or approved substitute.
B. Flush dryer receptacle, 30-amp, 125/250 VAC: Leviton No. 5207 with No. 84028 plate.

C. Flush range receptacle, 50-amp, 125/250 VAC: Leviton No. 5206 with No. 84028 plate.

D. Clock outlet: Leviton No. 5261CH.

2.5 DEVICE PLATES

A. Provide Leviton Series 84 stainless steel or approved substitute. Provide cast alloy or stamped metal plates on all exposed switches and receptacles.

PART 3 EXECUTION

3.1 INSTALLATION

A. Mounting:
   1. Mount all switches 46" above the finished floor to centerline of switch unless noted otherwise.
   2. Mount all receptacles 18" above the finished floor to centerline of receptacle unless noted otherwise.
   3. Mount weatherproof receptacles vertically.
   4. Work devices to nearest block course using proper type outlet boxes as specified under Section 260537. Check architectural and furniture drawings for counter (desk, special booth etc.) locations. Mount devices above work counters. Verify other special mounting conditions and locate devices as required.

B. Polarity: Properly wire all convenience outlets so that the hot wire, the neutral wire and the ground wire connect to the proper terminal on all receptacles.

C. Grounding: Install all receptacles in boxes specified under Section 260537, and install a No. 12 green ground wire from device grounding terminal back to the grounding bus in the panelboard and bond to outlet box.

D. Receptacles shown on the drawings as "special mounting height" shall be installed at mounting height as indicated on drawings. Where no mounting height is given and receptacles are above counters (or casework), they shall be mounted with centers 4" above top of counter. If the counter has a backsplash, receptacles shall be mounted with centers 4" above top of backsplash. Where special mounting height receptacles are not above counters and no mounting height is indicated, receptacle mounting heights shall match adjacent light switches or above counter receptacles. The Contractor shall coordinate the installation of all special mounting height receptacles with architectural design.

E. Install device plates in full contact with wall surface. Plates shall not project out from the wall.
F. Install device plates in full contact with surface-mounted box. Plates shall not project out from the edge of the box.

END OF SECTION 262726
PART 1 GENERAL

1.1 WORK INCLUDED

A. Provide horsepower-rated, quick-make, quick-break, safety switches provided with the number of poles and fuses as required.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS/EQUIPMENT

A. Safety switches shall be as manufactured by General Electric, Square D Company, Cutler-Hammer, or approved substitute.

B. For 208- and 240-volt circuits, use general-duty type switches with Class R fuse clips. For 480-volt circuits, use heavy-duty type switches with Class R fuse clips.

C. Switches shall have arc shields, shall be of enclosed construction and fusible or non-fusible as indicated. Switches shall be rated for either 250-volt AC or 600-volt AC service as required.

D. Safety switches for all part-winding or two-speed motors requiring remote disconnect to be similar to Square D Series HLL-660, six-pole.

E. Switches shall have Electrical Interlock Kit with one normally open and one normally closed contact.

F. All switches shall be capable of interrupting locked rotor current of motor which it serves.

G. Enclosures to be NEMA-1 for interior use and NEMA-3R for exterior use unless noted otherwise.

H. Provide dual-element Bussman type FRN (250 volt) or type FRS (600 volt) fuses for any fusible safety switch serving a motor circuit.

I. For non-motor loads, provide dual element Bussman type LPN (250 volt) or type LPS (600 volt).
PART 3 EXECUTION

3.1 INSTALLATION

A. Provide non-fusible switches at remote motor locations (raintight where required) as indicated on drawings.

B. Provide fusible disconnects at package A/C units, fused as specified on unit nameplate.

C. Mount switches to walls or adjacent to equipment enclosures using unistruts with a minimum of four bolts using toggle anchors for masonry construction, Phillips "Red Head" anchors for poured concrete construction and bolts, jumbo washers, lock washers and nuts for equipment enclosure mounting.

D. All safety switches to be identified with Bakelite nameplates.

END OF SECTION 262818
SECTION 264300
SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.1 WORK INCLUDED

A. Provide 3-phase, 4-wire Surge Protective Devices (SPDs) at the electrical panels as indicated on the panelboard schedules and on the riser diagram.

1.2 RELATED WORK

A. Section 262416 - Panelboards.
B. Section 260526 - Grounding and Bounding for Electrical Systems.

1.3 STANDARDS

A. UL compliance: Listed to UL 1449 4th Edition by an OSHA approved Nationally Recognized Test Lab (NRTL)
D. UL96A, Para. 13.1

1.4 SUBMITTALS

A. Submit product data and shop drawings as required by Section 260100.
B. Submittals shall include the following:
   1. Complete manufacturers’ data for each suppressor indicating part numbers and rated voltages and currents.
   2. Product performance analysis with graphic display of let-thru waveforms and peak clamping voltages for ANSI C62.41 tests, Categories A3 & B3 ringwaves and C1 & C3 impulses.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. SPDs shall be as manufactured by Current Technology, EFI Corporation, Liebert, or approved equal.
B. The suppressor manufacturer shall offer factory repair service for all units, which will include replacement for non-repairable sealed units.

2.2 WARRANTY

A. SPD devices shall be warranted for a minimum of 10 years.

2.3 SPECIFICATIONS

A. General:
1. SPD shall be internally fused, capable of allowing the suppressor's maximum rated transient current to pass through the suppressor without fuse operation. SPD shall be listed as a Type1 SPD without the need for upstream over current protection for safe operation.
2. Proper operation of the suppressor elements on each phase shall be indicated by a normally-on LED or lamp. Also, normally closed contacts shall be used for remote annunciation of suppressor failure.
3. The SPD shall be compatible with the electrical system voltage, current, and distribution configuration.
4. The SPD maximum continuous operating voltage shall be 115% of the nominal RMS voltage with no degradation. The MCOV value shall be a tested value as outlined in UL1449 3rd Edition section 37.7.3. The MCOV shall not be a claimed value based solely on the MCOV of the surge component used in the design, nor based solely on the 115% over voltage test outlined in UL1449.
5. The SPD shall be sine-wave tracking to provide added protection against oscillatory transients, such as Category A and B Ringwaves.
6. Failure of the SPD shall not cause any disruption of power.

B. Service Entrance SPD Devices:
1. The SPD shall have a surge current capacity of 100,000 amps (8 x 20 microsec) minimum per mode.
2. SPD devices shall meet or exceed the following operating characteristics and ratings: (Series Ratings)
3. The SPD shall be a Type1 listed SPD per UL1449 3rd Edition.
4. The SPD shall meet the requirements of UL96A, Para. 13.1
5. The unit shall not have more than 10% deterioration or degradation of the UL1449, 3rd Edition Voltage Protection Rating (VPR) due to repeated surges. Acceptable clamping values are shown below based on test procedures outlined in UL1449 3rd Edition.
### C. Distribution Panel SPD Devices:
1. The SPD shall have a surge current capacity of 60,000 amps (8 x 20 microsec) minimum per mode.
2. SPD devices shall meet or exceed the following operating characteristics and ratings: (Series Ratings)
3. The SPD shall be a Type1 or Type2 SPD per UL1449 3rd Edition.
4. The unit shall not have more than 10% deterioration or degradation of the UL1449, 3rd Edition Voltage Protection Rating (VPR) due to repeated surges. Acceptable clamping values are shown below based on test procedures outlined in UL1449 3rd Edition.

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PART 3 EXECUTION

3.1 INSTALLATION

A. Mount all 3-phase SPD devices in a separate cabinet attached to the panelboard it serves. The SPD shall not be internally mounted to the power or distribution panelboard. Cabinets for devices serving large service entrance main switchboards shall be located in a section of the switchboard where this option is made available by the manufacturer or be externally mounted to the switchboard. Cabinets for devices serving flush-mounted panelboards shall also be suitable for flush mounting. Cabinets shall comply with Section 262716 of the specifications.

B. Ground the SPDs and cabinets in accordance with the manufacturer’s instructions, the National Electrical Code (section 280 and 285), and wiring diagrams shown on the drawings.

C. Provide wiring to the remote monitor(s) in accordance with the manufacturer’s instruction and as shown on the drawings.

D. The SPD shall not include multiple replacement modules.

E. All conductors associated with SPDs shall be installed in conduit. Minimum conductor size shall be #8 AWG copper. Conductors shall be as short and as straight as possible with no unnecessary length or turns. A maximum length of 12 inches is required where possible.

F. SPDs shall be connected in parallel with main conductors. Service entrance SPDs shall incorporate the use of an internally mounted disconnect. Panelboard surge protectors shall be installed behind a minimum 60 amp overcurrent/disconnecting device. Where 12 inches of lead length is not possible utilization of a low impedance preassembled cable assembly is required to lower the clamping voltages of the installed system to acceptable levels. Lead length must include phase connection plus neutral or ground.

G. Mounting position of the SPD and overcurrent protection device shall be coordinated to minimize the total phase, neutral and ground cable lengths to achieve minimum installed system clamping voltages.

END OF SECTION 264300
PART 1 GENERAL

1.1 WORK INCLUDED

A. Provide labor, material, equipment and services necessary to provide all interior lighting fixtures, necessary hangers and lamps. Fixtures include all interior fixtures plus all exterior fixtures mounted to exterior wall or to structures connected directly to building.

1.2 SUBMITTALS

A. Submit for approval prior to purchasing fixtures complete fixture lists of fixtures proposed to be used. Include cuts of both specified fixture and proposed equivalent fixtures if fixtures other than those specified are submitted.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Provide lighting fixtures indicated by type on lighting fixture schedule on drawings.

2.2 EQUIPMENT REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Standards:
   1. ENERGY STAR certified.
   2. California Title 24 compliant.
   3. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
   4. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
   5. UL Listing: Listed for damp location.
   6. Recessed luminaires shall comply with NEMA LE 4.
   7. User Replaceable Lamps:
      a. Bulb shape complying with ANSI C78.79.
      b. Lamp base complying with ANSI C81.61.
C. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

D. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

E. Provide luminaires from a single manufacturer for each luminaire type.

F. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

G. Rated lamp life of 50,000 hours to L70.

H. Lamps dimmable from 100 percent to 0 percent of maximum light output.

I. Internal driver.

PART 3 EXECUTION

3.1 INSTALLATION REQUIREMENTS

A. Comply with NECA.

B. Fixtures shall be securely mounted as required by Section 410, NEC and as specified herein.

C. Fixtures mounted in a suspended ceiling shall be secured to the grid with approved clips as required by the NEC.

D. Fixtures shall be mounted in locations as shown on architectural reflected ceiling drawings.

E. Mount fixtures as called for in schedule on electrical drawings. Determine type of ceiling to be installed in each space from architectural drawings and schedules and furnish fixtures suitable for the exact type.

F. Receive, store, uncrate, and install lighting fixtures shown in schedule on drawings to be furnished by others.

G. Recessed fixtures in dropped ceiling areas shall be connected using Greenfield and No. 14 THHN wire. Greenfield shall be connected to fixture and outlet box. Each piece of Greenfield shall include in it a separate insulated green grounding conductor not smaller than No. 14 AWG for grounding continuity between fixture and conduit system. Grounding conductor shall be mechanically connected in a permanent and
effective manner to fixture and conduit system and shall be electrical continuous. No conduit shall enter a recessed fixture directly as this would prevent removal of fixture without disturbing balance of circuit.

H. Joints in fixture wiring shall be made using wire nuts, preinsulated Scotch locks, Ideal No. 30-410 crimps and No. 30-415 wrap caps, or other approved mechanical means of connection.

I. Adjustable type fixtures shall be adjusted by the Contractor to illuminate intended area to satisfaction of Owner.

J. Any adjustable outside area lights or lights mounted on building shall be adjusted at night by the contractor to satisfaction of Owner.

K. Recessed fixtures installed in exposed or concealed tee bar ceilings may not use ceiling grid to support fixtures. Fixtures shall be securely fastened to ceiling framework per NEC Article 410, and shall be supported as described in seismic detail.

L. Surface or recessed fixtures in or on plastered or drywall ceilings shall be supported in accordance with seismic fixture mounting details and shall not depend on ceilings for support.

M. Support fixtures in seismic zones per detail on drawings.

N. All light fixtures shall be grounded in accordance with the NEC. Any fixtures suspended from ceiling which do not include a separate ground wire shall be grounded in a method approved by section 250 of the NEC. Where the conduit is utilized as the ground with a hook pendant style mounting system, a separate ground conductor shall be bonded to the conduit where the conduit ceases to be continuous and routed to the fixture.

END OF SECTION 265100
SECTION 283102

FIRE ALARM SYSTEM (MODIFICATIONS TO EXISTING)

PART 1 GENERAL

1.1 SYSTEM

A. Fire alarm system is existing and is a Silent Knight.

1.2 WORK INCLUDED

A. Contractor to modify and add to system as shown on drawings including necessary conduit, wire, devices and control panel modifications.

B. Work under this contract to match existing unless devices required are not used, in which case, new items are to be provided to be compatible with existing system.

PART 2 PRODUCTS

2.1 COMPONENTS

A. New components are to be Silent Knight to match existing or as shown.
   1. Pull stations
   2. Smoke detectors (duct mounted) with remote indicator light mounted on wall
   3. Heat detectors (fixed temperature)
   4. Heat detectors (rate of rise) with 2 N.O. contacts
   5. Evacuation signals, flashing light
   6. Evacuation signals, horn-light combination: lamp, back box, horn

PART 3 EXECUTION

3.1 MODIFICATIONS

A. Modify system as shown on drawings and in accordance with manufacturers’ recommendations including conduit, boxes, wiring and accessories. Install wiring in conduits. Tag wires at junction points.

3.2 MAINTENANCE

A. Provide on-premises maintenance during normal working hours at no cost for a period of twelve months from date of completion.
3.3 ANNUNCIATOR SHOP DRAWINGS
   A. Submit a separate shop drawing of fire alarm annunciator layout, zone identification engraving, and signal light type and style for new devices being added to existing zones (under Base Bid for this Contract).

3.4 INSTALLATION DRAWINGS
   A. Subcontractor providing system for Electrical Contractor will prepare drawings utilizing architectural floor plans indicating component locations and all conduit and cable requirements.

3.5 TESTS
   A. Contractor to leave system in satisfactory working conditions.

END OF SECTION 283102
PART 1 - GENERAL

1.1 WORK INCLUDED

A. Excavating and rough-grading the site as indicated on the plans.

B. Installing drainage piping and appurtenances, and aggregate backfill.

C. Finish-grading.

1.2 REFERENCE DOCUMENTS

A. ASTM D 698 - Laboratory Compaction Characteristics of Soil Using Standard Effort.

B. ASTM D 1557 - Laboratory Compaction Characteristics of Soil Using Modified Effort.

1.3 EXISTING UTILITIES

Contractor shall field verify location and depth of underground utilities in areas of work. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations.

A. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair utilities to satisfaction of utility company.

B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies for shut-off of service if lines are active.

1.4 PROTECTION OF PERSONS AND PROPERTY

Barricade open excavation occurring as part of this Work and post warning lights.

A. Operate warning lights as recommended by authorities having jurisdiction.

B. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

1.5 ADDITIONAL UNDERCUTTING AND ENGINEERED FILL

Construction lines and cross section depths are shown on drawings. Any additional (remedial) undercutting and/or engineered fill required to provide proper sub grade shall be at the direct cost of the CONTRACTOR.
PART 2 – PRODUCTS

2.1 EXCAVATION MATERIAL

A. All excavation performed under this Section shall be considered **unclassified** excavation regardless of the nature of the material excavated.

B. All suitable material removed from excavation areas shall be used in the construction of embankments and in other such places as directed by the Engineer.

2.2 BORROW MATERIAL

Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations. If borrow materials are required then borrow shall be approved by a Geotechnical Engineer.

2.3 STRIPPING

Stripping shall consist of removing and stockpiling of topsoil material from the entire developed area of the site. Topsoil shall be stripped from areas to be graded or disturbed as necessary to remove it entirely. A minimum of 12” shall be removed from areas below the proposed structure, parking/driving pads, sidewalks, and all related improvements. In some areas, greater stripping depths may be required.

2.4 UNDERCUTTING

Undercutting shall consist of removing and disposing of unsatisfactory materials below grade in cut sections, from areas upon which fill is be placed, and may also include material excavated below the foundation elevation for pipe. Undercutting does not include the stripping, stockpiling and placing of topsoil.

PART 3 – EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, freezing temperatures or frost, and other hazards created by earthwork operations. Provide protective insulating materials as necessary.

B. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding areas.

D. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
3.2 EXCAVATION

A. Excavation to subgrade depths and bearing elevation indicated on drawings shall be unclassified.

B. Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, and obstructions.

C. 1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

D. Excavate for structures, pavements, and walks to indicated elevations and dimensions. Extend excavations for placing and removing concrete formwork, for installing services and other construction, and for inspections. Trim bottoms to required lines and grades to leave solid base to receive other work.

E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities.

F. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill may be used when approved by the Designer.

1. Fill unauthorized excavations under other construction or utility pipe as directed by the Designer.

F. Stockpile borrow materials and satisfactory soil materials, without intermixing, in shaped, graded, drained, and covered stockpiles. Stockpile soil materials away from edge of excavations.

3.3 BACKFILLS AND FILLS

A. Fill: Place and compact fill material in layers to required elevations.

B. Uniformly moisten or aerate subgrade and each subsequent fill or backfill layer before compaction to within 3 percent of optimum moisture content.

1. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 3 percent and is too wet to compact to specified dry unit weight.
C. Compaction: Place backfill and fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers. Compaction testing and proof rolling shall be in conformance with Specification 312313 sections 3.06 and 3.12, respectively.

1. Compact soil to not less than the following percentage of maximum dry density according to ASTM D 698:
   - Under lawn or unpaved areas, scarify and re-compact top 6 inches below subgrade and compact each layer of backfill or fill material at 90 percent.

D. Grading: Uniformly grade areas to a smooth surface, free from irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

E. Subbase and Base Courses: Under pavements and walks, place subbase course on prepared subgrade. Place base course material over subbase. Compact to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 698. In areas to receive more than six feet of fill, an average compaction of 98 percent Standard Proctor is required.

F. Under slabs-on grade, place drainage course on prepared subgrade: Compact to required cross sections and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 698. In areas to receive more than six feet of fill, an average compaction of 98 percent Standard Proctor is required.

G. Sinkhole repair: Contractor's geotechnical engineer shall provide recommendations and construction procedure for sinkhole closures. All sinkhole closures shall be in accordance with State of Tennessee standard sinkhole repair procedures.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: The Contractor shall engage a qualified testing and inspecting agency to perform field tests and inspections as required and to prepare test reports. Contractor shall coordinate all work and schedule with geotechnical engineer.

B. Allow testing agency to test and inspect subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.

C. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace material to depth required; recompact and retest until specified compaction is obtained.
3.5 PROTECTION AND DISPOSAL

A. Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

D. Disposal: remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

3.6 TOPSOIL SPREADING

A. Place topsoil in 6-inch lifts in areas indicated to receive plant beds or seed and 4-inch in sod areas.

B. "Box" and rake to remove rocks and debris greater than 1" diameter, roll and fine grade, ready for planting. Rough grading sub-contractor shall coordinate with the Prime Contractor and Finishing grading sub-contractor if work is separated so that topsoil is properly prepared prior to seeding operations. See Seeding and Sodding specification for additional requirements on topsoil preparation. A Harley Rake, Landscape Rake, or other measures that are pre-approved by the Owner are to be use for finish grading operations to prepare the topsoil for seeding operations.

C. Topsoil should not be spread more than 7 days prior to the time that finish grading is to take place, followed immediately by seeding and stabilization measures. Any topsoil that is spread and not immediately addressed with stabilization measures shall be the responsibility of the sub-contractor that originally spread the topsoil to regrade as needed for finish grading operation, seed and stabilization measures.

END OF SECTION 31 00 00 - EARTHWORK
PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

Provide all labor, material, and equipment to perform all clearing, grubbing, removal and disposal of vegetation, rocks, fences, structures, and debris within the limits of right-of-way and easement areas except objects and structures specified to remain as per instructions on the plans or Contract Documents. This work shall also include the preservation from injury or defacement of all vegetation and objects designated to remain.

1.2 RELATED SECTION

Section 31 00 00 – Earthwork

1.2 PROTECTION

A. Protect trees not marked for removal or located outside the limits of construction by approved means. If tree trunk or branch is cut or scarred then effected area shall be treated with a wound paint to prevent disease.

B. Protect location of benchmark and property corners to avoid damage by vehicular or equipment traffic.

C. Provide approved means of protection to existing structures including drainage inlets, culverts, road surfaces, sidewalks, curbing, and other structures from damage resulting from vehicular or equipment traffic during construction of this project.

D. Contractor shall conform to the requirements and standards for local, state and federal air pollution guidelines.

PART 2 – PRODUCTS

Not Used.

PART 3 – EXECUTION

3.1 CLEARING

Clear within the construction limits of public right-of-way construction easements through private properties, borrow pits, and stockpile areas as designated on the plans or Contract Documents. Any individual tree or group of trees that are to remain and are located within the limits of clearing shall be left undisturbed and protected by approved means.

3.2 GRUBBING

The area within the limits of grading shall be grubbed to a minimum depth of four (4) inches below existing ground line elevations to remove grass, roots, and other organic materials. All topsoil shall be stockpiled according to the requirements of Section 31 00 00 – Earthwork. At locations of proposed structures remove stumps and roots to a depth of twenty-four (24) inches below subgrade. Depressions created from grubbing shall be backfilled with suitable materials and compacted to required specifications.
3.3 TRIMMING OF TREES

A. Trees shall be trimmed or pruned to remove branches or roots that interfere with the construction procedure. Cut branches cleanly and leave as small an exposed section as possible. Coat cut sections of branches or roots over two (2) inch diameter with wound paint. All trimming and pruning shall conform to established specifications and standards.

B. Do not unnecessarily cut tree roots extending into areas of grading limits. Backfilling to cover disturbed tree root systems shall occur immediately after completion of construction activity.

C. Trees, shrubs, and other forms of landscaping treatment that are located outside of public right-of-way or construction easements through private property shall remain undisturbed. The contractor shall remove tree branches, limb brush, etc., that could create a construction hazard.

3.4 DISPOSAL

A. Dispose of trees, shrubs, and other waste materials at a site that is selected and properly permitted by the contractor. Failure to comply with this regulation shall result in the Contractor removing the illegally placed material at his own expense.

B. Burning of combustible material is restricted and shall not be allowed except as permitted by local approval agencies.

3.5 REMOVAL OF STRUCTURES AND OBSTRUCTIONS

A. The Contractor shall raze, remove and dispose of all buildings and foundations, structures, fences, and other obstructions any portions of which are on the right-of-way except utilities and those for which other provisions have been made for removal. All material from such Work designated to become the property of the Owner shall be removed without unnecessary damage in sections or in pieces which shall be readily transported and shall be stored and protected by the Contractor at specified places within the Project limits and all material not so designated shall become the property of the Contractor and shall be disposed of outside the limits of view of the Project. If the material is disposed of on private property, the Contractor shall secure written permission from the property owner.

B. The Owner reserves the right to dispose of buildings on any tract prior to their being torn down or removed by the Contractor.

C. Buildings and other structures which are designated on the plans or Contract Documents to be removed or disposed of by other agencies shall not be held as a charge or responsibility of the Contractor except that the Contractor waives any and all claims for interference, delay, or damage due to their removal or non-removal.
D. Foundations of buildings and structures shall be removed to a depth of not less than one (1) foot below natural ground except that within construction limits removal shall be to a depth of not less the two (2) feet below subgrade elevation. Basement floors shall be broken up to prevent holding of water. Basements or cavities left by structure removal shall be filled to the level of the surrounding ground and within the prism of construction and below subgrade elevation shall be compacted according to the requirements of Section 310000 – Earthwork.

3.6 REMOVAL OF CULVERTS, AND OTHER DRAINAGE STRUCTURES

Culverts and other drainage structures in use by traffic shall not be removed until satisfactory arrangements have been made to accommodate traffic.

3.7 REMOVAL OF PIPE

Pipe designated to become the property of the Owner shall be carefully removed and every precaution taken to avoid breaking or damaging the pipe. Pipes shall be removed and stored when necessary so that there shall be no loss or damage. The Contractor shall be required to replace sections damaged by negligence or by use of improper methods.

3.8 REMOVAL OF PAVEMENT, SIDEWALKS, CURBS, ETC., CONSTRUCTED OF PORTLAND CEMENT CONCRETE

A. All pavement, base course, sidewalks, curbs, gutters, etc., constructed of Portland cement concrete designated for removal shall be disposed of as directed.

B. Concrete pavement, parking strip, and base all with or without bituminous overlay, concrete curb and gutter, sidewalk, driveways, etc., shall be removed and disposed of as follows:

1. If the items are below subgrade elevation, but no more than two (2) feet, they shall be removed and disposed of.

2. If the items are more than two (2) feet below subgrade elevation they shall be broken into sizes not to exceed two (2) feet maximum dimension and remain in place unless it interferes with succeeding items of construction.

END OF SECTION 31 10 00 – SITE CLEARING
PART 1 - GENERAL

1.01 SCOPE

A. This Section includes preparing subgrade for Construction activities complete with excavation, Proof rolling, subgrade undercut and backfill, subgrade stabilization fabric, field quality control and appurtenances

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 31 00 00: Earthwork
B. Section 31 11 00: Clearing and Grubbing
C. Section 31 23 19: Dewatering
D. Section 31 25 00: Temporary Erosion and Sediment Control

1.03 REFERENCE STANDARDS

A. Unless Otherwise specified, the work for this Section shall conform to the applicable portions of the following Standard Specifications:

1. ASTM – ASTM International
2. AASHTO – American Association of State Highways and Transportation Officials
3. TDOT – Tennessee Department of Transportation 2006 Standard Specifications for Road and Bridge Construction

1.04 ALLOWABLE TOLERANCES

A. The finish subgrade shall be shaped to conform to plan grade and cross section within a tolerance of two (2) inches of the Finished grade shown on the Plans in lawn areas or areas not under buildings or pavement. All areas under buildings or pavement shall conform to plan grade and cross section within a tolerance of one (1) inch of the Finished grade shown on the Plans

1.05 SUBMITTALS

A. Test Reports

1. The testing lab shall provide the ENGINEER with two (2) certified copies of the sieve analysis for the backfill material. The testing of the material and the certification of the test results shall be performed by a testing laboratory approved by the ENGINEER.
2. The testing lab shall provide the ENGINEER with two (2) certified copies of the compaction and moisture tests of the backfill and subgrade materials. The testing of the materials and the certification of the test results shall be performed by a testing laboratory approved by the ENGINEER.

B. Samples

1. Submit sample of the proposed subgrade stabilization fabric measuring not less than 1 yd² in area, and the manufacturer’s certification that the proposed fabric meets or exceeds all requirements listed in Article 2.02 of this Section.

2. All Submissions shall be made not later than 10 working days prior to any installation.

1.06 PRODUCT STORAGE DELIVERY AND HANDLING

A. Geotextile fabric shall be furnished and stored in a wrap that will protect the geotextile from ultraviolet radiation and abrasion. The geotextile shall be covered with the aggregate base as per plan within two (2) weeks of its placement.

1.07 SOIL EROSION AND SEDIMENTATION CONTROL

A. The CONTRACTOR, at his expense, shall provide, maintain and remove such temporary and/or permanent soil erosion and sedimentation control measures as specified on the Plans or as determined by the ENGINEER.

B. The measures shall prevent surface runoff from carrying excavated materials into the waterways, to reduce erosion of the slopes, and to prevent silting in of waterways downstream of the Work.

C. The measures should include provisions to reduce erosions by the wind of all areas stripped of vegetation, including material stockpiles.

A. Comply with requirements of Section 31 25 00, Temporary Erosion and Sediment Control.
PART 2 – PRODUCTS

2.01 AGGREGATE MATERIALS

A. Aggregate materials, used for temporary gravel roadways and surface treatments, as shown on the Plans, shall be crushed limestone, natural aggregate, blast furnace slag or crushed concrete, meeting the requirements of Type A, Grading D or Type B, Grading D as specified in TDOT Section 903.05. Crushed concrete shall be free of all steel and other deleterious materials.

2.02 SUBGRADE STABILIZATION FABRIC

A. Subgrade stabilization fabric shall be composed of synthetic fibers formed into a woven fabric. The fibers shall be composed of 85% propylene or ester polymers. The geotextile shall conform to the following requirements listed below.

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST PROCEDURE</th>
<th>TEST RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grab Tensile</td>
<td>ASTM D4632</td>
<td>270 lbs. (min)</td>
</tr>
<tr>
<td>Elongation</td>
<td>ASTM D4632</td>
<td>15% (min)</td>
</tr>
<tr>
<td>Trapezoidal Tear</td>
<td>ASTM D4533</td>
<td>100 lbs. (min)</td>
</tr>
<tr>
<td>Puncture Strength</td>
<td>ASTM D4833</td>
<td>100 lbs. (min)</td>
</tr>
<tr>
<td>Apparent Opening Size</td>
<td>ASTM D4751</td>
<td>40-70U.S. Sieve</td>
</tr>
<tr>
<td>Permittivity</td>
<td>ASTM D4491</td>
<td>0.05 per sec (min)</td>
</tr>
<tr>
<td>Mullen Burst</td>
<td>ASTM D3786</td>
<td>400 psi (min)</td>
</tr>
</tbody>
</table>

PART 3 – EXECUTION

3.01 REMOVING STRUCTURES

A. Structures and sewers to be removed shall be called for on the Plans or as determined by the ENGINEER. Removal or abandonment of structures shall be in accordance with Section 018900, Site Construction Performance Requirements and Section 024100, Demolition and Protection.

3.02 HOLES

A. Earth removed during any phase of the excavation or removal operations, resulting in a hole or void, shall be replaced by backfilling to the proposed subgrade with suitable structural soil fill, which is defined as defined as inorganic, natural soil with maximum particle sizes of 4 inches, maximum gravel content of 15 percent, and maximum plasticity index (PI) of 35 as determined by ASTM D4318 and/or approved by the ENGINEER. Place the structural soil fill in loose lifts no greater than 10 inches. The materials shall be compacted to 98% of its maximum dry unit weight determined by ASTM D698. The moisture content of the fill materials should be controlled to within 2 percentage of the optimum moisture content as determined by ASTM Standard D698.
B. The furnishing, placing and compacting of the backfill material shall be at the CONTRACTOR’S expense.

3.03 SALVAGING AND STOCKPILING TOPSOIL

A. Topsoil shall be removed to the depth specified on the Plans. Topsoil salvaged in excess of that required for restoration, as shown on the Plans, will be permanently stockpiled by the CONTRACTOR at the location shown on the Plans.

B. Removing and salvaging topsoil shall be in accordance with Section 31 00 00, Earthwork.

3.04 SUBGRADE PREPARATION

A. All topsoil, muck peat and other unsuitable material within the construction area shall be removed, as shown on the Plans or as directed by the ENGINEER. All ice and snow shall be removed from the surface of the ground before any embankment fill is placed.

B. All topsoil, muck peat, and other unsuitable material shall be permanently stockpiled by the CONTRACTOR at the locations shown on the Plans.

C. Prior to receiving fill, all subgrade areas shall be compacted by rolling with a roller weighing not less than ten (10) tons.

D. The subgrade preparation work shall be completed ahead of placing embankment fill. Prior to placing fill material, the subgrade shall be shaped and compacted to the Plan cross section grade by approved mechanical means.

3.05 EXCAVATION

A. Excavation shall consist of all Work required to construct the earth grade and its appurtenances true to the lines, grades, and/or cross sections called for on the Plans and in accordance with these Specifications.

B. Excavation shall consist of the following items, any of which or all of which may be included or incidental to it:

1. Removing trees, stumps, hedges, roots, culverts, sewers, and miscellaneous structures.

2. Removing of all asphalt or concrete pavements, curbs, curb and gutters, sidewalks, and end headers.
3. Removing aggregate surfaces, salvaging and stockpiling topsoil, subgrade undercut, excavation for structures, trimming and finishing earth grade, rough grading, ditching, and restoration.

4. Transporting and the disposal of all unsuitable material.

C. All large stones, trees, stumps, brush, shrubs, logs, matted roots, other vegetation and debris occurring between lines three (3) feet outside the grading limits or as otherwise shown on the Plans shall be completely removed and properly disposed of as specified in Section 31 1100, Clearing and Grubbing.

D. All earth and other existing materials shall be excavated for the full depth and width of the cross section as shown on the Plans.

E. Excess excavated material shall be removed from the project by the CONTRACTOR along approved routes to stockpile sites approved by the OWNER. Transportation of excess excavation and maintenance of the stockpiling sites shall be considered incidental to the price paid for excavation and shall be as specified in Section 01 1900, Site construction Performance Requirements.

F. Construction, maintenance, removal and restoration of temporary haul roads to stockpile sites shall be considered incidental to the price paid for Rough Grading.

G. During the excavation operation, including the placing of the subbase, the Work area shall be kept free of water. A dewatering system shall be provided and maintained by the CONTRACTOR at his expense. The dewatering system shall remain in operation until the earthwork is completed.

3.06 PROOF ROLLING

A. After removal of topsoil or other overburden and prior to the construction of embankments, proof roll the existing subgrade with a minimum of 2 passes in each direction with a minimum of 10-ton, tandem axle dump truck.

B. Operate the equipment in a systematic manner to assure the number of passes over all areas, and at speeds between 2.5 and 3.5 miles per hour.

C. Proof rolling shall be done in the presence of the contractor’s Geotechnical Engineer. Rutting or pumping shall indicate unsatisfactory material and that material shall be undercut as determined by the GEOTECHNICAL ENGINEER, and replaced with suitable engineered fill material.

D. Perform proof rolling only when weather conditions permit. Do not proof roll frozen, wet, or saturated subgrades.

E. Materials degraded by proof rolling a wet or saturated subgrade shall be replaced by the CONTRACTOR as determined by the GEOTECHNICAL ENGINEER at no cost to the OWNER.
F. Notify the ENGINEER 48 hours prior to proof rolling.

3.07 SUBGRADE UNDERCUT EXCAVATION AND BACKFILLING

A. Unsuitable subgrade excavation shall be the operation of:
   1. Removing unsuitable soils as determined by the GEOTECHNICAL ENGINEER, below the level of the ground after topsoil has been stripped in fill areas.
   2. The removal of unsuitable soils below the subgrade elevations, as determined by the GEOTECHNICAL ENGINEER in cut areas after the planned finished subgrade has been established.

B. In fill areas, after topsoil has been stripped in accordance with Article 3.06 of this Section, the GEOTECHNICAL ENGINEER will inspect the embankment area to certify the adequacy of the native soils and to determine the extent of any additional excavation of unsuitable soils prior to placing the first lift of the embankment.

C. In cut areas after the planned finished subgrade elevation has been established by the mass grading operation and proof rolled in accordance with Article 3.06 of this Section, the GEOTECHNICAL ENGINEER will inspect the subgrade to determine the extent of any additional excavation of unsuitable soils.

D. The areas excavated of unsuitable material, unless otherwise specified in the Contract Documents, shall be backfilled with non-frost heaving structural soil fill, as defined above, and similar to the adjacent soil. The backfill shall be compacted to not less than 95% of the specified maximum dry unit weight, unless otherwise specified.

E. Subgrade undercut excavation and backfilling, as described in this Article, shall be considered incidental to the price paid for Rough Grading.

3.08 SUBGRADE STABILIZATION FABRIC

A. Place Subgrade Stabilization Fabric on prepared subgrade or subbase in the manner and at the location as called for on the Plans or as directed by the ENGINEER.

B. The fabric shall be laid smooth and free of tension stress, wrinkles or creases. Fabric strips shall be placed to provide a minimum overlap of 24 inches for each joint. Fabric shall be placed so that the upper strip will overlap the next lower strip.

C. Should the geotextile be damaged during construction, the torn or punctured section shall be repaired at CONTRACTOR’S expense by placing a piece of fabric that is sufficiently large to cover the damaged area plus two feet to adjacent undamaged geotextile in all directions.
D. The cost for Subgrade Stabilization Fabric, as described in this Article, shall be considered incidental to the price paid for Rough Grading.

3.09 TRIMMING AND FINISHING EARTH GRADE

A. After the earth grade has been constructed to the required grade, all stones and rocks more than three (3) inches in diameter, appearing on the surface of the subgrade shall be removed.

B. The finished earth grade shall be trimmed, all irregularities made smooth and the entire site completed to within 2 inches of the required lines, grades, and cross sections shown on the Plans.

C. The finished earth grade shall be prepared to drain freely and not allow ponding of water on the surface.

3.10 DITCHING

A. Ditching shall be constructed at the locations called for on the Plans or as determined by the ENGINEER. Ditches may be shaped by “Machine Grading” or another method approved by the ENGINEER to achieve the cross section, line and grade shown on the Plans.

B. The excess material from the ditch construction shall be stockpiled by the CONTRACTOR at the locations directed at no additional expense.

C. The ditch sections shall be graded to receive either topsoil and seed or surface gravel. The topsoil, seed, and mulch shall conform to the requirements specified on the Plans and in Section 32 92 19, Seeding. Surface gravel shall conform to the requirements specified on the Plans and in Section 32 15 00, Aggregate Surfacing.

3.11 ROADWAY AND SURFACE AGGERGATE

A. The CONTRACTOR shall furnish and install either Type A Aggregate- Grading A meeting the requirements of TDOT Section 903.05 as permanent stabilization for permanent roadways and site restoration, as noted on the Plans or as directed by the ENGINEER.

3.12 TESTING

A. During the course of the Work, the ENGINEER may require testing for compaction, sieve analysis and moisture content of the backfill and subgrade materials. The taking of samples and the testing required shall be performed by a testing laboratory suitable to the OWNER and approved by the ENGINEER.
B. The ENGINEER shall determine the location and number of samples to be made. The testing laboratory shall furnish the ENGINEER with two (2) certified copies of the results of all tests. Testing procedures shall conform to current TDOT 2006 Standards Specifications for Road and Bridge Construction. The cost for testing and sampling shall be at the expense of the CONTRACTOR.

C. The Maximum unit weight when used as a measure of compaction or density of soils shall be understood to mean the maximum dry unit weight per cubic foot as determined by ASTM D698, modified to include all the material passing the 1-inch sieve.

D. Perform one-in-place density test every 5,000 sq ft. for each 8-inch-thick, loose lift of fill material. Perform one-in-place density test per 200 ft. of trench length and a minimum of one per drainage structure for each 8-inch-thick, loose lift of fill material.

E. Upon completion of fill embankments under structures and pavement, the completed subgrade shall be proof rolled in accordance with section 3.06 of this specification prior to the placement of base stone.

### DEFECTIVE WORK

#### A. Any portions of the backfill, subbase or subgrade which is deficient in the specified density shall be corrected by methods meeting the approval of the ENGINEER.

#### B. Any extra testing of sampling required by the ENGINEER, because of deficiencies, shall be at the CONTRACTOR’S expense.

END OF SECTION 31 23 13 – SUBGRADE PREPARATION
1.01 SCOPE

A. This section includes all dewatering work complete with design of dewatering systems, construction and operation of dewatering systems, abandonment of dewatering systems, protection of personnel and structures, environmental protection and restoration.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 31 00 00: Earthwork
B. Section 31 23 33: Trenching and Backfilling
C. Section 31 25 00: Temporary Erosion and Sediment Control

1.03 DESIGN OF DEWATERING CONSTRUCTION

A. Any Geotechnical Investigations made in relation to this project are provided as reference documents. Interpretations of all data and reports, performing any additional investigations, and obtaining any additional data for construction purposes is the responsibility of the CONTRACTOR.

B. The CONTRACTOR shall be responsible for the complete design of all structures and methods proposed for dewatering the project site, including the implementation of all materials, tools and equipment proposed for use in the Work. Temporary wiring associated with the dewatering shall comply with the applicable portions of the National Electrical Code.

1.04 SOIL EROSION AND SEDIMENTATION CONTROL

A. All dewatering systems design and construction shall conform to the provisions of Section 31 25 00, Temporary Erosion and Sediment Control. Where applicable, the CONTRACTOR shall obtain and pay for all permits and inspections for dewatering construction in accordance with the provisions of and all local government agencies having jurisdiction. No additional claim for compensation shall be allowed because of the CONTRACTOR’S failure to obtain or pay for such permits and inspections.

B. The CONTRACTOR, at his expense, shall provide, maintain and remove such temporary and/or permanent soil erosion and sedimentation control measures as specified on the Plans or as determined by the ENGINEER. The measures shall prevent surface runoff from carrying excavated materials into the waterways, to reduce erosion of the slopes, and to prevent silting in of waterways downstream of the Work. Also, the measures should include provisions to reduce erosion by the wind of all areas stripped of vegetation, including material stockpiles.
1.05 FEDERAL, STATE, AND LOCAL REGULATIONS

A. Dewatering operations shall conform to the requirements of all federal, state, and local agencies having jurisdiction. Dewatering water discharged to streams, drains or sewers may require permits from federal, state or local agencies having jurisdiction.

B. The CONTRACTOR shall comply with all water quality requirements prior to discharging dewatering water. The CONTRACTOR shall be responsible for all testing and treatment required to meet water quality requirements prior to discharge. No discharges to sanitary sewers will be allowed without prior approval of local agencies with jurisdiction for the sanitary sewers.

1.06 PROTECTION

A. Take all steps necessary, during the Work of this Section, to protect surrounding property and adjacent buildings, private water supplies, roads, drains, sewers, structures and appurtenances. Adequate measures shall be taken to protect such property and construction from the effects of the dewatering operations.

1.07 SUBMITTALS

A. Submit detailed plans indicating proposed type and location of dewatering wells, type and location of collection/conveyance piping, and point of disposal of pumped water. Do not begin any dewatering work until submittals and supporting data have been reviewed by ENGINEER.

B. Dewatering system shall be designed by a professional with a minimum of seven years documented experience in the installation and design of dewatering systems. Submittal shall be signed and sealed by a registered professional engineer, stating that the proposed dewatering method is adequate to perform the required tasks.

PART 2 – PRODUCTS (NOT INCLUDED)

PART 3 – EXECUTION

3.01 GENERAL

A. Provide electrical power from local utility. Provide stand-by power and any other required auxiliary dewatering equipment to assure continuous dewatering capability. Dewatering, where required, shall be continuous. Dewatering will not be stopped during work stoppage without approval of the ENGINEER. Coordinate construction operations to minimize duration and extent of dewatering required. Dewatering wells are to use properly designed filters to prevent the migration of soil fines into the well.
3.02 MONITORING AND CONTROL

A. During dewatering operations, monitor ground water level with piezometers to ensure the design of specified groundwater elevation is maintained. Install monitoring wells with screens below the excavation level as required. Install wells at minimum 200-foot intervals located between dewatering wells. Provide access to monitoring wells by ENGINEER.

B. Modify dewatering operation if geotechnical instrumentation or survey measurements indicate movement of structures, sheeting or embankments, or inability to lower groundwater as specified.

C. Inspect wells and lines on a daily basis to ensure integrity and water tightness. Keep fittings and connections watertight to ensure release of sulfide to atmosphere from groundwater does not occur.

3.03 EXISTING DRAINAGE CONDITIONS

A. Prior to beginning any work, verify in the field, the location, type and capacity of all existing drainage facilities and conditions which will affect the Work of this Section. No allowances shall be made for conditions found during the progress of the dewatering operations because of the CONTRACTOR'S failure to verify such conditions.

3.04 EXISTING STRUCTURES AND UTILITIES

A. The CONTRACTOR shall make field verification of all existing structures and utilities at the site of the Work which are scheduled to remain and which may be affected by the Work of this Section. The CONTRACTOR shall be responsible for any damage to existing structures and/or utilities caused because of his Work and shall repair such damage at his expense to the satisfaction of the ENGINEER or utility owner.

3.05 DRAINAGE OF EXCAVATIONS

A. The CONTRACTOR shall maintain all finished excavation work free of water during the preparation of the subgrade and until the completion of the Work. No ground or surface water shall be discharged into any existing sanitary sewer. No unit of Work shall be constructed underwater except as otherwise determined by the ENGINEER. Provide and maintain adequate dewatering equipment to remove and dispose of all surface or groundwater entering excavation, trenches or other parts of the Work. Each excavation shall be kept dry during subgrade preparation and continually thereafter until the construction is complete.
B. All excavations which extend down to or below the static groundwater elevations shall be dewatered by lowering and maintain the groundwater level beneath such excavations a distance of not less than 12 inches below the bottom of the excavation. Drainage system methods shall not cause any damage to wells or adjacent property. All outlet drainage piping and conduit shall be kept clean and free from sediment. The CONTRACTOR shall be held responsible for the condition of all existing pipes, conduits and structures which he may use for drainage.

3.06 DEWATERING SUMPS AND PUMP WELLS

A. Sumps and pump wells used as a part of the dewatering system shall be strongly sheathed and braced to protect the construction while in use. Tops of well casings must be covered to prevent animals and debris from entering and shall be 2 to 3 feet above ground. Sumps and wells, when abandoned, shall be backfilled and compacted to the satisfaction of the ENGINEER.

3.07 DRILLING

A. Methods used in drilling wells associated with dewatering systems shall be the responsibility of the CONTRACTOR and shall be acceptable to the ENGINEER. Drilling methods shall insure proper placement of well materials and shall not involve displacement of earth formations. Drilling shall be done with first class equipment of proper type and in good condition, acceptable to the ENGINEER.

3.08 PUMPING

A. Equipment for pumping and pumping methods associated with dewatering systems shall be the responsibility of the CONTRACTOR and shall be acceptable to the ENGINEER. The CONTRACTOR shall construct or furnish adequate discharge piping to conduct and dispose of the water so as to prevent damage to existing structures or property. Pumping equipment shall be first class, acceptable to the ENGINEER, of proper type and size for the Work and in good condition. Provide all anchors and supports for pumping equipment.

3.09 FILLING AND GRADING

A. Upon completion of dewatering Work for the Project, abandon and/or fill all holes, trenches, ditches, and other earth excavations created by the Work of this Section and not scheduled to remain. Do all filling, back filling and grading to restore excavations and earth banks to the lines and levels indicated on the Plans and as determined by the ENGINEER. All earth fills shall be compacted to a density equal to that of the surrounding undisturbed earth.

END OF SECTION 31 23 19 – DEWATERING
PART 1 - GENERAL

1.01 SCOPE

A. This Section includes open trench construction for utility installation, complete with trenching, sheeting, bracing, bedding, bedding materials, backfilling, backfill materials, and compaction.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 31 00 00: Earthwork
B. Section 31 11 00: Clearing and Grubbing
C. Section 31 23 19: Dewatering
D. Section 31 25 00: Temporary Erosion and Sediment Control
E. Section 33 40 00: Storm Utility Drainage Piping

1.03 EMERGENCY ACCESS

A. Unless otherwise specified, the Work for this Section shall conform to the applicable portions of the following Standard Specifications:
   1. ASTM – ASTM International
   2. AASHTO – American Association of State Highways and Transportation Officials
   3. TDOT – Tennessee 2006 Standard Specifications for Road and Bridge Construction

1.04 TEST REPORTS

A. The testing laboratory shall provide the ENGINEER with two (2) certified copies of the test results of the compaction of the backfill.

B. The testing for compaction and the certification of the test results shall be performed by a testing laboratory approved by the ENGINEER.

1.05 MIX DESIGN

A. Submit mix designs for any concrete or flowable fill mixtures to be used on the Project. Include certified test results for seven day and 28 day strengths, together with any technical information for admixtures.
1.06 SOIL EROSION AND SEDIMENTATION CONTROL

A. The CONTRACTOR, at his expense, shall provide, maintain and remove such temporary and/or permanent soil erosion and sedimentation control measures as specified on the Plans of as determined by the ENGINEER.

B. The measures shall prevent surface runoff from carrying excavated materials into waterways, to reduce erosion of the slopes, and to prevent silting in of drainage ways downstream of the Work.

C. The measures should include provisions to reduce erosions by the wind of all areas stripped of vegetation, including material stockpiles.

D. Comply with requirements of Section 31 25 00, Temporary Erosion Sediment Control.

PART 2 PRODUCTS

2.01 GRANULAR MATERIALS

A. Granular material gradation shall conform to the grading requirements for Select Granular Backfill Material per TDOT requirements. The granular material shall be reasonably free from organic and otherwise deleterious materials, and it shall be approved by the ENGINEER prior to use.

2.02 CRUSHED STONE BEDDING

A. Crushed, angular, natural stone material, meeting the requirements of Type A Aggregate, Grading D per TDOT Section 903.05.

2.03 CONCRETE

A. In accordance with TDOT Section 604, use Class A, 3,000 psi strength, Type I cement, 3” maximum slope; 6.5% air content +/-1.0%; no admixtures without the ENGINEER’s approval.

2.04 Flowable Fill for Backfilling

A. Materials:
   1. Fly Ash: Fly Ash shall have a maximum loss on ignition of 12% and meet the other requirements of ASTM C618 (Class F).
   2. Water: Water shall meet the requirements of ASTM C94.
   3. Cement: ASTM C150 or C595, Type I or IA.
B. Mixture (Strength 100-120 psi):
   1. Fly Ash: 2000 lbs/c.y. min
   2. Cement: 70 lbs/c.y. min
   3. Water: Sufficient water to produce desired flowability, 700 lbs/c.y. ±

C. The temperature of the flowable fill mix as manufactured and delivered shall be at least 50°F. The flowable fill can be mixed by pugmill, central concrete mixer, ready mix truck, turbine mixer, or other acceptable equipment or method.

PART 3 EXECUTION

3.01 DEWATERING

A. Open cut trench excavation shall include the site clearing and grubbing, the excavating of all materials encountered, the supporting and protecting of all structures and/or utilities encountered above and below the ground surface, and the removal of water from the construction site.

B. The trenching operation shall commence at the downstream or outlet end of the new Work and proceed upstream, unless otherwise specified on the Plans or directed by the ENGINEER.

C. The trench shall be excavated in reasonably close conformity with the lines and grades specified on the Plans or as established by the ENGINEER.

D. The excavated materials shall be temporarily stores along the trench in a manner that will not cause damage to trees, shrubs, fences, improvements, utilities, private property, public property or traffic. The excavated materials shall not be placed at such locations that will endanger the trench banks by imposing loads thereon.

E. The trench shall be sufficient width to provide adequate working space to permit installation of the pipe and the compaction of the bedding material under and around the pipe. However, for rigid pipe, the width of the trench from below the pipe bedding to 12 inches above the top of the pipe shall not exceed the following dimensions:

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<tbody>
<tr>
<td>6-inch thru 12-inch pipe</td>
<td>30 inches wide</td>
</tr>
<tr>
<td>15-inch thru 36-inch pipe</td>
<td>Outside diameter plus 16 inches</td>
</tr>
<tr>
<td>42-inch thru 60-inch pipe</td>
<td>Outside diameter plus 20 inches</td>
</tr>
<tr>
<td>Over 60-inch pipe</td>
<td>Outside diameter plus 24 inches</td>
</tr>
</tbody>
</table>
F. To support the additional load of the backfill when the maximum trench width as specified for rigid pipe is exceeded, the CONTRACTOR shall install, at his expense, concrete encasement which shall completely surround the pipe and shall have a minimum thickness at any point of ¼ of the outside diameter of the pipe or four (4) inches, whichever is greater, or at his expense, install another type bedding, approved by the ENGINEER. The concrete encasement shall consist of 3,000 psi strength concrete.

G. For flexible pipe, the minimum width shall be not less than the greater of either the pipe outside diameter plus 16 inches or the pipe outside diameter times 1.25, plus 12 inches. The maximum trench width for flexible pipe shall not exceed the minimum width by more than 6-inches.

H. To support the additional load of the backfill when the maximum trench width as specified for flexible or semi-rigid pipe is exceeded, the CONTRACTOR shall install, at his expense, crushed stone pipe bedding to the full width between undisturbed trench walls or at least 2.5 pipe diameters on each side of the pipe.

I. When, through the CONTRACTOR’s constructions procedure or because of unsuitable existing ground conditions, it becomes impossible to maintain alignment and grade properly, the CONTRACTOR, at his expense, shall excavate below the normal trench bottom grade and shall fill the void with a large size aggregate or 3,000 psi concrete as approved by the ENGINEER to insure that the pipe when laid in the proper bedding will maintain correct alignment and proper grade.

J. All trench excavations, including those for shafts and structures, shall be adequately braces and/or sheeted where necessary to prevent caving or squeezing of the soil.

3.03 SHEETING, SHORING, and BRACING

A. The CONTRACTOR shall furnish, place and maintain at all times such sheeting, shoring, and bracing of the trench and/or shaft as may be required for safety of the workmen and for protection of the new Work or adjacent structures, including pavement, curbs, sidewalks, pipe lines, conduits next to or crossing the trench, and the protection and safety of pedestrian and vehicular traffic.

B. The CONTRACTOR shall be responsible for the complete design of all sheeting, shoring and bracing Work. The design shall be appropriate for the soil conditions, shall be of such strength, quality, dimensions and spacing as to prevent caving or loss of ground of squeezing within the neat lines of the excavation, and shall effectively restrain movement of the adjacent soil. Prior to installing the sheeting, shoring or bracing, the CONTRACTOR shall submit Plans for this Work to the ENGINEER for informational purposes only.

C. Sheetling, shoring, bracing, and excavation shall conform to the current federal or state regulations for safety.
D. Where indicated on the Plans and where necessary in the Work, install and leave sheeting, shoring, and bracing in place. No extra compensation shall be paid to CONTRACTOR for sheeting, shoring or bracing left in place.

E. Supports for pipes, conduits, etc., crossing the trench shall conform to the requirements of the owners of such facilities, and if necessary, shall be left in place.

F. The furnishing, placing, bracing, maintaining, and removing of sheeting, shoring, and trenching materials shall be at the CONTRACTOR’s expense. The CONTRACTOR shall not remove the trench sheeting, shoring and bracing unless the pipe has been properly bedded, and the trench backfilled to sufficiently support the external loads. Also, that sheeting, shoring, and bracing material shall not come in contact with the pipe, but shall be installed so that no concentrated loads or horizontal thrusts are transmitted to the Pipe.

3.04 PIPE BEDDING

A. Install and compact in six-inch layers. Particular care shall be taken to assure filling and tamping all spaces under, around, and above the top of the pipe. Work in and around pipe by hand to provide uniform support.

B. Rigid Pipe Bedding: Per Plans

C. Flexible Pipe Bedding: Per TDOT D-PG-3

3.05 BACKFILLING TRENCHES

A. Backfill material shall be placed on section of bedded pipes only after such pipe bedding and backfill materials have been approved by the ENGINEER.

B. The trench backfilling shall follow the pipe laying as closely as possible. However, at no time shall the pipe laying in any trench precede backfilling of that trench by more than 100 feet, unless otherwise directed by the ENGINEER.

C. Backfilling shall not be done in freezing weather except by permission of the ENGINEER. Frozen materials shall not be used in trench backfilling.

D. The following trench backfill specification are for use in that portion of the trench beyond the scope of the pipe bedding requirements which normally stops at a point 12 inches above the top of pipe.

1. Backfill material to be placed above pipe bedding shall be free of cinders, ashes, refuse, boulders, roots, stumps, trees, timbers, brush, debris, or other extraneous materials which in the opinion of the ENGINEER, are unsuitable.
2. Rocks or stones having a dimension larger than six (6) inches shall not be placed within three (3) feet of the top of the pipe.

3. Large stones may be placed in the remainder of the trench backfill only if well separated and arranged so that no interference with backfill settlement will result.

E. Backfill trench with structural soil fill materials, compacted to 95% of the material’s maximum dry density as determined by ASTM Standard D698 (Standard Proctor). Structural soil fill is defined as inorganic, natural soil with maximum particle sizes of 4 inches, maximum gravel content of 15 percent, and maximum plasticity index (PI) of 35 as determined by ASTM D4318. Place the structural soil fill in loose lifts no greater than 10 inches. The moisture content of the fill materials should be controlled to within 2 percentage of the optimum moisture content as determined by ASTM Standard D698.

F. Unless otherwise specified on the Plans or as directed by the ENGINEER, the trench backfill shall be carried to the adjacent existing ground.

G. Compaction of the backfill will not be paid for separately, but shall be considered incidental to the Work of backfilling and shall include all the Work of manipulating the soil, to obtain the specified densities. No additional compensation will be allowed for any delay required to obtain the specified moisture content or the specified density.

H. Where backfill or bedding as shown on the plans or specified is to be flowable fill, care shall be used to avoid displacing any pipes or structures due to fluid pressure. Pipes in backfill areas may need to be secured to avoid the buoyancy effect.

3.06 CLEANUP

A. Immediately following the placing and compacting of the backfill, the excess material shall be removed and disposed of by the CONTRACTOR, at his expense, as specified in Section 01 89 00, Site Construction Performance Requirements. The construction area shall be leveled and left in a neat workmanlike condition.

B. At a seasonally correct time, approved by the ENGINEER, the disturbed areas shall be raked, having topsoil placed thereon, fertilized and seeded per the requirements of Section 32 92 19, Seeding, or the area shall be stabilized with surface gravel, as noted on the Plans, immediately following completion of trench backfilling.
3.07 Field Testing

A. During the course of the Work, the ENGINEER may require testing for compaction or density of the backfill. The taking of samples and the testing required shall be performed by a testing laboratory suitable to the OWNER and approved by the ENGINEER. The cost for testing and sampling shall be at the expense of the CONTRACTOR.

B. The maximum unit weight, when used as a measure of compaction or density of soils, shall be understood to mean the maximum dry unit weight per cubic foot as determined by ASTM D698.

C. Perform one-in-place density test per 200 feet of trench length and a minimum of one per drainage structure for each 10-inch thick loose lift of fill material.

3.08 DEFECTIVE WORK

A. Any portion of the trench backfill which is deficient in the specified density shall be corrected by methods meeting the approval of the ENGINEER.

B. Any extra testing or sampling required because of deficiencies shall be at the CONTRACTOR’s expense.

END OF SECTION 31 23 33 – TRENCHING AND BACKFILLING
PART 1 GENERAL

1.01 SCOPE OF WORK

A. This WORK shall consist of temporary measures needed to control erosion and water pollution. These temporary measures shall include, but not be limited to, berms, dikes, dams, sediment basins, fiber mats, netting, gravel, mulches, grasses, slope drains, straw bales, turbidity barriers, temporary gravel construction entrance/exits, inlet filters, ditch sediment traps and other erosion control devices or methods. These temporary measures shall be installed at the locations where needed to control erosion and water pollution during the construction of the PROJECT, and as directed by ENGINEER, and as shown on the DRAWINGS.

B. The Erosion Control Plan presented in the DRAWINGS serves as a minimum for the requirements of erosion control during construction. CONTRACTOR has the ultimate responsibility for providing adequate erosion control and water quality throughout the duration of the PROJECT. Therefore, if the provided plan is not working sufficiently to protect the PROJECT areas, then CONTRACTOR shall provide additional measures as required to obtain the required protection. CONTRACTOR shall include in the BID price for erosion control a minimum of all items shown on the Erosion Control Plan and any additional items that may be needed to control erosion and water pollution.

1.02 RELATED SECTIONS

A. The following is a list of SPECIFICATIONS which may be related to this section:

1. Section 31 00 00 - Earthwork
2. Section 31 10 00 - Site Clearing
3. Section 31 23 13 – Subgrade Preparation
4. Section 31 23 19 – Dewatering
5. Section 31 23 33 – Trenching and Backfilling
6. Section 32 15 00 – Aggregate Surfacing
7. Section 32 92 19 - Seeding
8. Section 33 40 00 – Storm Drainage Systems

1.03 REFERENCES

A. The following is a list of standards which may be referenced in this section:

2. ASTM American Society for Testing and Materials
1.04 REQUIREMENTS OF REGULATORY AGENCIES

A. The CONTRACTOR, at his expense, shall secure all permits, and post all bonds or deposits to comply with all state and local “Soil Erosion and Sedimentation Control,” requirements being Tennessee Water Quality Act TCA 69-13-108 and 40 CFR 122 and 124 and Section 402 – Federal Clean Water Act, as amended and the National Pollution Discharge Elimination System (NPDES) Rules for storm water discharges from construction activity.

B. Comply with all requirements of the agency having jurisdiction. Owner may withhold payment to CONTRACTOR equivalent to any fines resulting from non-compliance with applicable regulations.

1.05 PERFORMANCE REQUIREMENTS


B. Put preventative measures in place as soon as possible after disturbance of surface cover before precipitation occurs.

C. Control increased storm water runoff due to disturbance of surface cover due to construction activities for this Project.

D. Prevent runoff into storm and sanitary sewer systems, including open drainage channels, in excess of actual capacity or amount allowed by authorities having jurisdiction, whichever is less. Anticipate runoff volume due to the most extreme short term 24-hour rainfall event that might occur within 10 years.

E. Minimize wind, water, and vehicular erosion of soil on project site due to construction activities for this Project.

F. Prevent erosion of soil and deposition of sediment on other properties caused by water leaving the Project site due to construction activities for this Project. Prevent windblown soil from leaving the project site. Comply with fugitive dust ordinances of agencies having jurisdiction. Prevent tracking or flowing of mud and sediment onto public or private roads, sidewalks or pavements outside of the Project site.

G. Prevent sedimentation of waterways on or off the project site, including rivers, streams, lakes, ponds, open drainage ditches, storm sewers and sanitary sewers. If sedimentation occurs, install or correct preventative measures immediately at no cost to the OWNER. Comply with requirements of agencies having jurisdiction.

H. Maintain temporary preventative measures until permanent measures have been established. Remove temporary measures when permanent measures have been established.
I. If erosion or sedimentation occurs due to non-compliance with these requirements, remove deposited sediment or restore eroded areas at no cost to the OWNER.

1.06 SUBMITTALS

A. Submit the following information:
   1. Erosion Control Plan.
   2. Construction schedule for Erosion Control Scheduling.
   4. Plan for disposal of waste material.
   5. Product data for materials proposed for use.
   6. All applicable permits for Erosion Control.

1.05 SCHEDULING

A. Sequencing Plan:
   1. CONTRACTOR shall submit a sequencing plan for approval for erosion control in conformance with CONTRACTOR’s overall Construction Plan for approval by ENGINEER.
   2. Changes to the Erosion Control Sequencing Plan may be considered by ENGINEER only if presented in writing by the CONTRACTOR.

B. Temporary Erosion Control:
   1. When so indicated in the CONTRACT DOCUMENTS, or when directed by ENGINEER, CONTRACTOR shall prepare construction schedules for accomplishing temporary erosion control WORK including all maintenance procedures.
   2. These schedules shall be applicable to clearing and grubbing, grading, structural WORK, construction, etc.

C. CONTRACTOR shall submit for acceptance the proposed method of erosion control on haul roads and borrow pits and a plan for disposal of waste material.

D. CONTRACTOR shall be required to incorporate all permanent erosion control features into the PROJECT at the earliest practicable time as outlined in the accepted schedule. Temporary erosion control measures shall then be used to correct conditions that develop during construction.
E. WORK shall not be started until the erosion control schedules and methods of operations have been accepted.

PART 2 PRODUCTS

2.01 MATERIALS

A. All materials shall be submitted for approval prior to installation.

B. Materials may include hay bales, straw, fiber mats, fiber netting, wood cellulose, fiber fabric, gravel, and other suitable materials, and shall be reasonably clean, free of deleterious materials, and certified weed free.

2.02 GRASS SEED:

A. Temporary grass cover (if required) shall be a quick growing species, suitable to the area, in accordance with local criteria and permit requirements, which will provide temporary cover, and not compete with the grasses sown for permanent cover.

B. All grass seed shall be approved by ENGINEER and in accordance with local regulations prior to installation per TDEC Region II Requirements below.

<table>
<thead>
<tr>
<th>Region II</th>
<th>Zone</th>
<th>Best</th>
<th>Marginal</th>
<th>Mix (lb/ac PLS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Slopes and Poor/Shallow</td>
<td>Aug 25 - Sept 15</td>
<td>Aug 20-Oct 25</td>
<td>Pensacola bahiagrass (100)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Feb 15 – Mar 21</td>
<td>Feb 1 - Apr 15</td>
<td>Bermudagrass hulled (40)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Korean lespedeza (30)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Feb 15 – Mar 21</td>
<td>Feb 1 – Apr 15</td>
<td>Bermudagrass hulled (30)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Korean lespedeza (20)</td>
</tr>
<tr>
<td></td>
<td>Roadside Channels</td>
<td>Aug 15 – Oct 15</td>
<td>Feb 15 – Apr 15</td>
<td>KY 31 Fescue (150)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bermudagrass (hulled) (20)</td>
</tr>
<tr>
<td></td>
<td>Temporary Seeding</td>
<td>May 1 – Sept 15</td>
<td>April 15 – Oct 1</td>
<td>German millet (30)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sudangrass (40)</td>
</tr>
<tr>
<td></td>
<td>Temporary Seeding</td>
<td>Oct 31 – Feb 15</td>
<td>Oct 15 – Mar 1</td>
<td>Annual Ryegrass (40)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Foxtail millet (30)</td>
</tr>
</tbody>
</table>

C. Fertilizer and soil conditioners shall be approved by ENGINEER and in accordance with local regulations prior to installation.
2.03 STRAW BALES

A. Rectangular straw bales, 14 by 18-inch minimum, bound with wire or string along the long dimension. Secure with wood stakes minimum 2 by 2-inch in cross section and length as required to securely fix position of bale.

2.04 SILT FENCE

A. Polypropylene geotextile fabric, resistant to common soil chemicals, mildew, and insects; non-biodegradable; in longest lengths possible; meeting the following requirements:
1. Average opening size: 30U.S. Std. Sieve 600 µm), maximum: ASTM D4751.
2. Permittivity: 0.05sec⁻¹, minimum; ASTM D4491.
3. Ultraviolet Resistance: Retaining at least 70 percent of tensile strength; ASTM D4355 after 500 hrs exposure.
4. Tensile Strength: 100lb –f (445 N) minimum, in cross-machine direction; 124 lb-f (551 N) minimum in machine direction; ASTM D4632
5. Elongation: 15 to 30 percent; ASTM D4632
6. Tear Strength: 55lb-f (244 N) minimum; ASTM D4533

B. Posts shall be 2 by 2-inch cross section hardwood stakes, minimum 3 feet long.

2.05 TURBIDITY BARRIER

A. Geotextile fabric curtain suspended from floatation devices at the water surface and held in a vertical position by a ballast chain in the lower hem. Turbidity barrier curtain shall meet the following minimum requirements unless otherwise specified on the plans.
1. Consist of vinyl laminate on 1000 denier polyester fabric weighing 18 ounce per square yard minimum.
2. Tensile strength of fabric shall be 220 lbs minimum.
3. Edges of fabric to be reinforced with minimum 5/8-inch diameter polypropylene rope.
5. Buoyancy blocks providing buoyancy of 18 lbs/l.f.
6. Length of curtain (water depth)5-feet.
2.06 DEWATERING DISCHARGE FILTER BAG
   A. UV-stabilized, non-woven geotextile bag to filter sediment from water prior to discharging. Geotextile fabric shall meet the following minimum average roll requirements:

   1. Tensile Strength: 180 lb-f minimum; ASTM D4632
   2. Puncture Strength: 105 lb-f minimum; ASTM D4833
   3. Mullen Burst: 350 psi minimum; ASTM D3786-87
   4. Trapezoidal Tear: 70lb-f minimum; ASTM D4533
   5. Flow Rate: 80gal/min/sf. Minimum; ASTM D4491
   6. Permittivity: 1.4 sec minimum; ASTM D4491
   7. Apparent Opening Size: 100 U.S. Std. Sieve (150um) maximum; ASTM D4751
   8. UV-Stability: 70% retained strength; ASTM D4355 after 500 hours.

2.07 EROSION CONTROL BLANKETS
   A. Machine produced blanket with a consistent thickness of evenly distributed straw or coconut fiber as specified. Unless otherwise specified on the Plans, the erosion control blanket shall have the following minimum properties:

   1. Double net 100% straw blanket.
   2. Top and bottom photodegradable polypropylene netting, 1.64 lbs/1,000 sft. Approximate weight.
   3. 100% agricultural straw 0.5 lbs/sy
   4. Stitch spacing: 1.5 inches on centers

   B. Pegs shall be 6-inch long. Hardwood pegs.

2.08 BONDED FIBER MATRIX
   A. Bonded fiber matrix (FFM) shall consist of long strand, residual, softwood fibers joined together by a high-strength, nontoxic adhesive. The BFM shall be 100% biodegradable, and be nontoxic to fish, wildlife, and humans. Upon drying the matrix shall form a high strength, porous and erosion resistant mat that shall not inhibit the germination and growth of plants. The BFM shall retain its form despite re-wetting.

   B. Bonded fiber matrix shall consist of:

   1. Seed and Fertilizer per Section 32 9219, Seeding.
   2. Wood Fiber Mulch: Thermo-mechanically delibrated long, softwood fibers manufactured from select northern softwood wood chips.
   3. Polyacrylamide Binder: Site specific, fully biodegradable, polyacrylamides (PAM’s) binders, with cross linking long organic jute fibers.

   C. Materials shall be mixed at the rate of 80lbs/acre of PAM binder and 2500 lbs/acre of wood fiber mulch.
2.09 INLET FILTER FABRIC

A. The filter fabric shall be constructed of 100% continuous polyester needle-punched non-woven engineering fabric and follow the guidelines in the American Society for Testing and Materials (ASTM) D1117-99; Standard Guide for Evaluating Nonwoven Fabrics. The filter fabric shall be fabricated to provide a direct fit with the drainage structure cover. The filter fabric shall have the following minimum physical properties:

1. Tensile Strength: 80lb-f minimum; ASTM D4632
2. Elongation: 50 percent minimum; ASTM D4632
3. Puncture Strength: 45 lb-f minimum; ASTM D4833
4. Mullen Burst: 350 psi minimum; ASTM D3786-87
5. Trapezoidal Tear: 70 lb-f minimum; ASTM D4533
6. Flow Rate: 80 gal/min/sf. Minimum; ASTM D4491
7. Permittivity: 1.4 sec minimum; ASTM D4491
8. Apparent Opening Size: 100 U.S. Std. Sieve (150 μm), ASTM D4750
9. UV-Stability: 70% retained strength; ASTM D4355 after 500 hours.

2.10 ACCEPTABLE MANUFACTURES

A. Acceptable manufacturers include the following:

1. Turbidity Barrier: Tough Guy Type II by AER-flo Canvas Products, Inc. or equal.
2. Wood fiber mulch: EcoFibre by Canfor Corporation, or equal.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine site and identify existing features that contribute to erosion resistance; maintain such existing features to the greatest extent possible.

B. Except in areas to be cleared, do not remove, cut, deface, injure or destroy trees or shrubs without the ENGINEER'S approval. Protect existing trees or shrubs that are to remain and which may be injured, bruised, defaced, or otherwise damaged by construction operations, with suitable fences or other means as approved by the ENGINEER.

3.02 PREPARATION

A. Schedule work so that the soil surfaces are left exposed for the minimum amount of time. Place permanent soil and sedimentation control measures as soon as practical.
3.03 GENERAL

A. Do not discharge excavation ground water to the sanitary sewer, storm sewer, or to rivers, streams, etc. without authorization from entering any storm drain, river, stream, etc. directly by the use of silt fences or other suitable methods.

B. Sedimentation control devices shall be installed prior to CONTRACTOR beginning Work. All soil Erosion and Sedimentation Control Devices shall be maintained in an effective functioning condition at all times during the course of the Work.

C. Immediately bring earthwork to final grade and protect sideslopes and backslopes from erosion. Plan and conduct earthwork to minimize duration of exposure of unprotected soils.

D. All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to ensure continued performance of their intended function.

E. OWNER will monitor CONTRACTOR’s erosion control and WORK methods.
   1. If the overall function and intent of erosion control is not being met, OWNER will require CONTRACTOR to provide additional measures as required to obtain the desired results.
   2. Costs for any additional erosion control measures shall be paid for at contract unit prices.

F. The erosion control features installed by CONTRACTOR shall be adequately maintained by CONTRACTOR until the PROJECT is accepted.

G. Working In or Crossing Watercourses and Wetlands:
   1. Construction vehicles shall be kept out of watercourses to the extent possible.
   2. Where in-channel WORK is necessary, precautions shall be taken to stabilize the WORK area during construction to minimize erosion.
      a. The channel (including bed and banks) shall always be restabilized immediately after in-channel WORK is completed.
   3. Where a live (wet) watercourse must be crossed by construction vehicles during construction, a Temporary Stream Crossing shall be provided for this purpose.

3.04 DUST CONTROL

A. Keep dust down at all times, including during non-working periods. Sprinkle or treat, with dust suppressants, the soil at the site, haul roads, and other areas disturbed by operations. Dry power brooming is not permitted.
3.05 INSTALLATION - GENERAL

A. Install silt fences, ditch sediment traps, check dams, inlet filters, temporary gravel construction entrance/exits, turbidity barriers, erosion control blankets and other soil erosion control devices detailed on the plans. Maintain devices until permanent control measures are completed and effectively established. Remove temporary control devices after permanent measures are established. Remove and replace temporary control devices if they become ineffective at no additional cost to the OWNER.

B. Install temporary erosion and sedimentation control devices per the manufacturer’s recommendations. Advise ENGINEER of any discrepancies between the manufacturer’s recommendations and the details on the plans and install per ENGINEER’S resolution of discrepancy.

3.06 MAINTENANCE

A. Inspect preventative measures a minimum of once per week and within a minimum of 24 hours after every rainfall. Any soil erosion control measures damaged or rendered ineffective shall be immediately repaired or removed and replaced at no additional cost.

3.07 INSTALLATION OF EROSION CONTROL BLANKETS

A. Erosion control blankets shall be pegged at the pattern and rate as recommended by the manufacturer, however, at a minimum, blankets shall be pegged at the rate of 1.75 pegs per square yard of blanket, unless otherwise indicated on the plans.

3.08 APPLICATION OF BONDED FIBER MATRIX

A. The slop shall be prepared and graded prior to application of bonded fiber matrix (BFM). Mixture of wood fiber mulch and polyacrylamide binder shall be blended, with the appropriate amount of seed and fertilizer per Section 32 9219, Seeding, according to manufacturer’s recommendations.

B. The BFM shall be hydraulically applied to the soil as a viscous mixture, creating a continuous, three-dimensional blanket that adheres to the soil surface. The BFM shall be mixed and applied at the rate as specified in Article 2.06 unless otherwise indicated on the Plans. The resulting coverage must be at least 1/8-inch-thick over the entire surface area. The BFM shall be applied in two applications from alternate directions to eliminate shadowing, and shall be applied when no rain is expected for 12 hours.

3.09 DEWATERING DISCHARGE

A. Should it be necessary for the CONTRACTOR to do any dewatering during the course of construction, the CONTRACTOR shall filter all discharge through a discharge filter bag or other sediment control device that will filter all discharge water. No dewatering discharge shall be allowed to flow unfiltered from the construction site.
3.10 PROJECT COMPLETION

A. Remove all temporary soil erosion and sedimentation control devices as soon as the permanent measures have been established.

3.10 PROTECTION OF ADJACENT PROPERTIES

A. Properties adjacent to the site of a land disturbance shall be protected from sediment deposition.

B. In addition to the erosion control measures required on the DRAWINGS, perimeter controls may be required if damage to adjacent properties is likely, and may include, but is not limited to:

1. Vegetated buffer strip around the lower perimeter of the land disturbance.
   a. Vegetated buffer strips may be used only where runoff in sheet flow is expected and should be at least twenty (20) feet in width.

2. Sediment barriers such as straw bales, erosion logs, and silt fences.

3. Sediment basins and porous landscape detention ponds.

4. Combination of above measures.

3.11 CONSTRUCTION

A. Stabilization of Disturbed Areas:

1. Temporary sediment control measures shall be established prior to time of exposure/disturbance.

2. Permanent stabilization/erosion protection measures shall be established within fourteen (14) days after final grading of areas.

B. Stabilization of Sediment and Erosion Control Measures:

1. Sediment barriers, perimeter dikes, and other measures intended to either trap sediment or prevent runoff from flowing over disturbed areas shall be constructed as a first step in grading and be made functional before land disturbance takes place.

2. Earthen structures such as dams, dikes, and diversions shall be stabilized within five (5) days of installation.

3. Stormwater outlets shall also be stabilized prior to any upstream land disturbing activities.
C. Stabilization of Waterways and Outlets:
   1. All onsite stormwater conveyance channels used by CONTRACTOR for temporary erosion control purposes shall be designed and constructed with adequate capacity and protection to prevent erosion during storm and runoff events.
   2. Stabilization adequate to prevent erosion shall also be provided at the outlets of all pipes and channels.

D. Storm Sewer Inlet Protection: All storm sewer inlets which are made operable during construction or which drain stormwater runoff from a construction site shall be protected from sediment deposition by the use of filters.

E. Construction Access Routes:
   1. Wherever construction vehicles enter or leave a construction site, a Stabilized Construction Entrance is required.
   2. Where sediment is transported onto a public road surface, the roads shall be cleaned thoroughly at the end of each day.
   3. Sediment shall be removed from roads by shoveling or sweeping and be transported to a sediment controlled disposal area.
   4. Street washing shall be allowed only after sediment is removed in this manner.

3.12 DISPOSITION OF TEMPORARY MEASURES

A. All temporary erosion and sediment control measures shall be disposed of within thirty (30) days after final site stabilization is achieved or after the temporary measures are no longer needed as determined by OWNER.

B. Trapped sediment and other disturbed soil areas resulting from the disposition of temporary measures shall be permanently stabilized to prevent further erosion.

C. Substantial Completion of Erosion Control Measures:
   1. At the time specified in the CONTRACT DOCUMENTS, and subject to compliance with specified materials and installation requirements, CONTRACTOR shall receive a Substantial Completion Certificate for temporary erosion control measures.
   2. Maintenance of Erosion Control Measures after Substantial Completion: CONTRACTOR shall be responsible for maintaining temporary erosion control measures as specified in the DRAWINGS and CONTRACT DOCUMENTS until such time as WORK has been accepted by OWNER.
D. Final Completion and Acceptance of Erosion Control Measures:

1. After ENGINEER and OWNER have determined that the drainage area has stabilized, CONTRACTOR shall remove all remaining temporary erosion control measures.

2. Any damage to the site shall be repaired to the satisfaction of ENGINEER and at no cost to OWNER.

END OF SECTION 31 25 00
PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

This work shall consist of furnishing all labor, material, and equipment required to construct a bituminous concrete pavement on a prepared surface or subgrade in accordance with these Specifications and in reasonably close conformity with the lines, grades, thickness, and typical cross sections shown on the Plans.

1.2 RELATED SECTIONS

None

1.3 SUBMITTAL

A. Provide copies of material certificates signed by material producer and Contractor certifying each material item complies with or exceeds the specifications.

B. Job Mix Formula:

a. The Contractor shall submit to the Engineer, at least 14 working days prior to the scheduled start of production of any asphaltic paving mixture, the Job Mix Formula and Laboratory Design prepared in accordance with the Marshall Mix Design Method (AASHTO T 245). The Job Mix Formula shall include 50% recycled asphalt by weight. In addition, the Contractor shall submit an asphalt barge certification with temperature-viscosity curve for each mixture to the Engineer for approval.

The following information shall be furnished:

1. The source and description of all materials to be used in the mix.

2. The gradations and approximate proportions of the raw materials as intended to be combined in the paving mixture.

3. A single percentage of the combined mineral aggregate passing each specified sieve. The combined aggregate gradation shall be plotted on a gradation chart with sieve sizes raised to the 0.45 power to assure a well graded mix.

4. The Loss on Ignition (LOI) results on the combined aggregate of the Grading “D” mix used as a wearing course.

5. The Bulk Specific Gravity, Apparent Specific Gravity and absorption on the combined mineral aggregate in the paving mixture (AASHTO T 84 AND T 85).

6. A single percentage of asphalt by weight of total mix intended to be incorporated in the completed mixture.
7. The maximum specific gravity of the asphalt mixture (AASHTO T 209).

8. A single temperature at which the mixture is intended to be discharged from the plant.

9. Evidence that the completed mixture will conform to all specified physical requirements set forth in this specification.

10. The tensile strength ratio (TSR) indicating the stripping and moisture susceptibility characteristics of the mix.

The Laboratory Design must be prepared and signed by a Certified Laboratory Technician.

C. The approved job mix formula shall remain in effect until a change is authorized by the Engineer. The Contractor, at any time after construction has started, may request that the job mix formula be revised, providing evidence is shown that the revision is necessary and the revised aggregate gradation will meet all applicable gradation requirements.

D. The submitted job mix formula shall include test data showing that the material as produced will meet the requirements specified in this specification when tested in accordance with AASHTO T 245. The bulk specific gravity of the laboratory compacted bituminous mixture (Marshall Specimen) shall be determined in accordance with AASHTO T 166.

E. The percent voids in the total mix shall be based on the maximum specific gravity of the bituminous mixture (Rice Gravity) as determined by AASHTO T 209. The voids in the mineral aggregate (VMA) shall be calculated using the effective specific gravity of the aggregates.

1.4 SAMPLING AND TESTING

A. The Contractor shall be responsible for the quality of construction and materials incorporated therein.

B. The Contractor shall perform all necessary sampling and testing for acceptance purposes, in addition to performing quality control tests procedures through final project acceptance.

C. The Contractor shall provide a nuclear gauge and a qualified operator for determining densities of compacted mixes. The Contractor shall furnish a core drill and take samples from test strips to calibrate the nuclear gauge. All densities will be reported using the corrected nuclear gauge readings.

D. The Engineer reserves the right to acquire samples of asphalt cement concrete mixes to check the Contractor’s compliance with these specifications.
PART 2 – PRODUCTS

2.1 MINERAL AGGREGATE BASE

A. Aggregates for Mineral Aggregate Base shall be hard durable particles or fragments of stone, slag, gravel, or chert, together with such material as manufactured sand or other fine material naturally contained, or added thereto as needed to conform to this specification.

B. Individual materials shall meet the requirements specified below:

1. Crushed stone shall be free of silt and clay. The coarse aggregate portion (retained on the No. 4 sieve) of the stone shall have a percentage of wear of not more than 50, and when subjected to five alternations of the sodium sulfate soundness test, the weighted percentage of loss shall not exceed 15.

2. Crushed slag shall be free of silt and clay and shall meet the quality requirements of crushed stone. It shall be reasonably uniform in density and shall have a dry-rodded weight of at least seventy (70) pounds per cubic foot.

3. Gravel and chert shall be screened and all oversize material may be crushed and fed uniformly back over the screen. The coarse aggregate portion shall have a percentage of wear of not more than 50, and when subjected to five alternations of the sodium sulfate soundness test, the weighted percentage of the loss shall not exceed 15. The portion of the material passing the No. 40 sieve shall be non-plastic, or shall have a liquid limit of not more than thirty and a plasticity index of not more than eight (8).

C. If fine aggregate, coarse aggregate or binder, in addition to that present in the base material, is necessary in order to meet the gradation or density requirements or for satisfactory bonding of the material, it shall be uniformly blended with the base course material at the mixing plant by a mechanical feeder to maintain a uniform flow on the belt to the mixer. Blending of materials on the stockpiles or in the pits by bulldozer, clamshell, dragline or similar equipment will not be permitted.
D. The composite gradation of the Mineral Aggregate Base shall be as follows:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2&quot;</td>
<td>100</td>
</tr>
<tr>
<td>2&quot;</td>
<td>85-100</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>60-95</td>
</tr>
<tr>
<td>1&quot;</td>
<td>50-80</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>40-65</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>20-40</td>
</tr>
<tr>
<td>No. 4</td>
<td>9-18</td>
</tr>
<tr>
<td>No. 16</td>
<td></td>
</tr>
<tr>
<td>No. 100</td>
<td></td>
</tr>
</tbody>
</table>

2.2 PRIME COAT

A. Bituminous Material

1. Cut-Back Asphalt, Grade RC-70 or RC-250, shall conform to the requirements of AASHTO M 81 or M 82, for the type and grade specified.

2. Emulsified Asphalts, Grade AE-P or CAE-P.
   
a. Anionic Emulsified Asphalts shall conform to all the requirements of AASHTO M 140, for the type and grade specified.
   
b. Cationic Emulsified Asphalts shall conform to the requirements of AASHTO M 208, for the type and grade specified.

3. Temperature ranges shall be as follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE-P and CAE-P</td>
<td>60-140</td>
</tr>
<tr>
<td>RC-70</td>
<td>80-150</td>
</tr>
<tr>
<td>RC-250</td>
<td>100-175</td>
</tr>
</tbody>
</table>

B. Aggregate, Size 7, 8 or 78.

Aggregate shall consist of crushed stone, crushed slag, or crushed gravel meeting the quality requirements of ASTM D 692.
2.3 TACK COAT

A. Bituminous Material

1. Cut-Back Asphalt, Grade RC-70 or RC-250, shall conform to the requirements of AASHTO M 81 or M 82, for the type and grade specified.

2. Emulsified Asphalts, SS-1, SS-1H, CSS-1 or CSS-1H.
   a. Anionic Emulsified Asphalts shall conform to all the requirements of AASHTO M 140, for the type and grade specified.
   b. Cationic Emulsified Asphalts shall conform to the requirements of AASHTO M 208, for the type and grade specified.

3. Temperature ranges shall be as follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC-70</td>
<td>80-150</td>
</tr>
<tr>
<td>RC-250</td>
<td>100-175</td>
</tr>
<tr>
<td>SS-1, SS-1H</td>
<td>60-140</td>
</tr>
<tr>
<td>CSS-1H</td>
<td></td>
</tr>
</tbody>
</table>

2.4 ASPHALT CEMENT

Asphalt cements shall conform to the requirements of AASHTO MP-1 for PG64-22. When asphalt cement PG70-22 or PG76-22 is specified, the asphalt cement shall conform to AASHTO MP-1. Modification of the asphalt shall be accomplished by properly blending styrene butadiene (SB), styrene butadiene styrene (SBS) or styrene butadiene rubber (SBR) to PG64-22 base asphalt.

A. In addition to the above requirements, the PG70-22 and PG76-22 shall meet the following:

<table>
<thead>
<tr>
<th></th>
<th>PG70-22</th>
<th>PG76-22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ring &amp; Ball Softening Point (°F), Minimum</td>
<td>128</td>
<td>135</td>
</tr>
<tr>
<td>Elastic Recovery by means of Ductilometer, % minimum</td>
<td>40</td>
<td>58</td>
</tr>
<tr>
<td>Screen Test</td>
<td></td>
<td>No Lumps Retained</td>
</tr>
</tbody>
</table>
B. Test Procedures

1. Elastic Recovery by means of a Ductilometer

Condition the ductilometer and samples to be tested at the temperature prescribed for that material. Prepare the brass plate, mold, and briquette specimen in accordance with ASTM D113, “Ductility of Bituminous Materials”. Keep the specimen at the specified test temperature for 85 to 90 minutes. Immediately after conditioning, place the specimen in the ductilometer and proceed to elongate the sample to 20 centimeters. The rate of pull shall be 5 cm/min. unless otherwise stated. After the 20-centimeter elongation has been reached, stop the ductilometer and hold the sample in its elongated position for 5 minutes. At this time, clip the sample approximately in half by means of scissors or other suitable cutting devices. Let the sample remain in the ductilometer in an undisturbed condition for one hour. At the end of this time period, retract the half sample specimen until the two broken ends touch. At this point, note the elongation in centimeters.

Calculate the percent recovery by the following formula:

\[
\% \text{ Recovery} = \frac{(20 - X)}{20} \times 100
\]

\[X = \text{observed elongation after rejoining the sample, cm}\]

2. Screen Test

The procedure shall be to pour a 1000 gram sample heated to 275°F through a No. 10 sieve. There shall be no lumps or particles retained on the sieve.

3. Viscometer Test

In addition to the above, a rotational viscometer, meeting ASTM D4402 requirements with a thermostatically controlled cell will be required at all hot mix asphalt plants using modified liquid asphalt products. A minimum of one test per day shall be run on samples taken from the contractor’s storage tank or from a sampling port after the material is in-line blended if the grade of the material is being changed as the hot-mix plant. Viscosity values shall be in the range from 650-3000 cP for PG70-22, and, 1000 to 3000 cP for PG76-22 at 275°F.

C. Materials Certification

A certification shall be furnished to the Engineer stating that the asphalt cement furnished meets Project Specifications.
D. If a SBR modifier is used, the SBR shall be pre-blended with the asphalt cement or added by means of an “in-line” motionless mixer. The “in-line” mixer shall be a Komax Model No. 30715A, Ross LPD Motionless Mixer, Koch Static Mixer or other approved equal. The “in-line” motionless mixing unit shall provide a homogeneity value of 0.15 or less. The mixing unit shall be equipped with a port(s) for obtaining representative samples of the blended material in accordance with AASHTO T40. The mixer shall be oil jacketed. The mixer shall have a minimum diameter of ½ inch larger that the asphalt supply line onto which it is installed.

2.5 PLANT MIX BASE (HOT MIX)

A. Aggregate for plant mix base shall consist of coarse aggregate fine aggregate and mineral filler when required.

B. Coarse Aggregate (Aggregate Retained on the No. 4 Sieve)

1. Coarse aggregate shall be crushed stone, crushed granite, crushed gravel, crushed slag or combination of these materials.

2. Coarse aggregate shall conform to the quality requirements of ASTM D 692 except that the sodium sulfate soundness loss on limestone shall not exceed nine (9) percent, and the aggregate shall contain no more than five (5) percent soft or nondurable particles.

3. Crushed gravel shall consist of siliceous particles processed from washed material. At least seventy (70) percent by count of the gravel retained on the No. 4 sieve shall have a minimum of two fractured faces, one of which must be fractured for the approximate average diameter or thickness of the particle.

4. Virgin coarse aggregate for Grading A and A-S mixes shall be crushed stone, crushed slag, or a combination thereof.

5. After drying in the plant, the aggregate retained on the No. 4 sieve shall have a loss of not more than one (1) percent by weight when washed over a No. 8 sieve.

C. Fine Aggregate (Aggregate Passing the No. 4 Sieve)

1. Fine aggregate shall consist of limestone fines, natural sand, sand manufactured from stone, gravel, or slag, or combinations thereof. It shall consist of hard, tough grains free from injurious amounts of deleterious substances, and when subjected to five cycles of the sodium sulfate soundness test, it shall have a weighted loss of no more than twelve (12) percent.

2. In natural sand and manufactured sand, the percentage of material finer than No. 200 sieve shall not exceed five (5) percent.
3. Virgin fine aggregate used in Grading A and A-S mixes shall consist of crushed stone or crushed slag only and shall be stored separately from the coarse aggregate.

4. The amount of deleterious substances in natural sand shall not exceed the following limits:

   1. Clay Lumps ...................................... 0.5%
   2. Coal & Lignite ................................. 0.5%
   3. Other Deleterious
       Substances .................................... 3.0%

D. The Combined Grading.

1. The combined gradings may be achieved by the appropriate combination of coarse aggregate with the appropriate fine aggregate.

2. The Contractor shall establish a gradation for each aggregate used in the mix. The aggregate gradation tolerance on each sieve is listed below.

   3/8” sieve and larger  ±10%
   No. 4 sieve  ±7%
   No. 8 sieve  ±5%
   No. 30 sieve  ±4%
   No. 200 sieve (CA)  ±2%
   No. 200 sieve (FA)  ±4%
3. The gradation of the coarse and fine fractions of aggregate shall be such that when combined in proper proportion the resultant mixture will meet one of the following gradings, as specified:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grading A</td>
</tr>
<tr>
<td>2-1/2&quot;</td>
<td>100</td>
</tr>
<tr>
<td>2&quot;</td>
<td>100</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>81-100</td>
</tr>
<tr>
<td>1-1/4&quot;</td>
<td></td>
</tr>
<tr>
<td>1&quot;</td>
<td></td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>50-71</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>35-50</td>
</tr>
<tr>
<td>No. 4</td>
<td>24-36</td>
</tr>
<tr>
<td>No. 8</td>
<td>13-27</td>
</tr>
<tr>
<td>No. 30</td>
<td>7-17</td>
</tr>
<tr>
<td>No. 50</td>
<td></td>
</tr>
<tr>
<td>No. 100</td>
<td>0-10</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-4.5</td>
</tr>
</tbody>
</table>

E. The specified mineral aggregate and asphalt cement shall be combined in such proportions as to produce mixtures within the following design composition limits.

<table>
<thead>
<tr>
<th>Grading</th>
<th>Combined Mineral Aggregate</th>
<th>Asphalt Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>“A-S”</td>
<td>96.3-97.7</td>
<td>2.3-3.7</td>
</tr>
<tr>
<td>“A”</td>
<td>95.8-96.7</td>
<td>3.3-4.2</td>
</tr>
<tr>
<td>“B-M”</td>
<td>93.8-95.8</td>
<td>4.2-6.2</td>
</tr>
<tr>
<td>“B-M2”</td>
<td>93.8-95.8</td>
<td>4.2-6.2</td>
</tr>
<tr>
<td>“CW”</td>
<td>93.8-95.8</td>
<td>4.2-6.2</td>
</tr>
</tbody>
</table>
F. In addition, the combination of materials shall be such that when combined with the required amount of bitumen, the resultant mixture shall have:

<table>
<thead>
<tr>
<th>Mix</th>
<th>Min. Stability Lbf *</th>
<th>Void Content *</th>
<th>Min. % VMA *</th>
<th>Dust-Asphalt Ratio **</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;B-M&quot;</td>
<td>2000</td>
<td>3-5.5</td>
<td>13.5</td>
<td>0.6-1.5</td>
</tr>
<tr>
<td>&quot;B-M2&quot;</td>
<td>2000</td>
<td>3.5-5.5</td>
<td>13.5</td>
<td>0.6-1.2</td>
</tr>
<tr>
<td>&quot;CW&quot;</td>
<td>1500</td>
<td>3-5</td>
<td>13.0</td>
<td>0.6-1.5</td>
</tr>
</tbody>
</table>

* Tested in accordance with AASHTO T 245 with 75 blows with the hammer on each end of the test specimen, using a Marshall Mechanical Compactor.

** The dust to asphalt ratio is the percent of the total aggregate sample that passes the 200 mesh sieve as determined by AASHTO T 11 divided by the percent asphalt in the total mix.

2.6 ASPHALTIC CONCRETE SURFACE (HOT MIX)

A. Aggregate for asphaltic concrete surface courses shall consist of a combination of coarse and fine aggregate and mineral filler when required or specified. A minimum of three sizes of aggregates shall be required for all mix designs.

B. Coarse Aggregate (Aggregate Retained on the No. 4 Sieve)

1. Coarse aggregate shall be crushed stone, crushed slag, crushed granite, crushed gravel, crushed quartzite, crushed gneiss, other approved non-skid aggregates or combination of these materials.

2. Coarse aggregate shall conform to the quality requirements of ASTM D 692 with the following exceptions and additions.

   a. Crushed limestone shall have a sodium sulfate soundness loss not exceeding nine (9) percent.

   b. Material retained on the No. 4 sieve shall contain a maximum of 20% elongated pieces (length greater than five times the average thickness).

   c. Crushed gravel shall consist of siliceous particles processed from washed material, of which at least 70% by count, of the material retained on the No. 4 sieve shall have a minimum of two fractured faces, one of which must be fractured for the approximate average diameter or thickness of the particle. The addition of pea gravel or uncrushed particles will not be permitted. The absorption of the crushed gravel retained on the No. 4 sieve shall not exceed five (5) percent when tested in accordance with AASHTO T 85.

   d. Crushed slag coarse aggregate shall contain no more than 20%, by weight, of glassy particles.
e. After drying in the plant, the aggregate retained on the No. 4 sieve shall have a loss of not more than 1% by weight when washed over a No. 8 sieve in accordance with the coating test.

C. Fine Aggregate (Aggregate Passing the No. 4 Sieve)

1. Fine aggregate shall consist of, natural sand, fines prepared from stone, slag, gravel, granite, quartzite, gneiss, other approved non-skid aggregates, or combinations thereof. It shall consist of hard, tough grains free from injurious amounts of clay, loam or other deleterious substances, and when subjected to five cycles of the sodium sulfate soundness test, it shall have a weighted loss of no more than twelve (12) percent. Manufactured sand shall have no more than five (5) percent passing the No. 200 sieve when tested in accordance with AASHTO T 11.

2. Natural sand shall be washed. The natural sand shall be so graded that not more than five (5) percent will be retained on the No. 4 sieve.

3. Fine aggregate consisting of natural sand will be tested in accordance with AASHTO T 11 and the amount of material finer than a No. 200 sieve shall not exceed four (4) percent by weight.

4. The amount of deleterious substances in natural sand shall not exceed the following limits:
   1. Clay Lumps.................................0.5%
   2. Coal & Lignite.........................0.5%
   3. Other Deleterious Substances...............3.0%

5. Agricultural limestone, when used as a portion of the fine aggregate, shall be manufactured from sound, durable stone and shall be crushed so that at least 85% will pass the No. 8 sieve and at least 50% will pass the No. 30 sieve.

D. The Combined Grading.
1. The several aggregate fractions shall be sized, graded, and combined in such proportions that the resulting composite blend will meet one of the following grading requirements, as specified.

2. The Contractor shall establish a single value for each sieve size required in the mix for each aggregate stockpile. The aggregate gradation tolerance on each sieve is listed below.

- 3/8" sieve and larger ±10%
- No. 4 sieve ±7%
- No. 8 sieve ±5%
- No. 30 sieve ±4%
- No. 200 sieve (CA) ±2%
- No. 200 sieve (FA) ±4%

3. When gradings “D” or “E” are used for the surfacing of shoulders or for other non-traffic lane construction, the design may be modified as approved by the Engineer.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grading D</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td></td>
</tr>
<tr>
<td>5/8&quot;</td>
<td>100</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>95-100</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>80-93</td>
</tr>
<tr>
<td>No. 4</td>
<td>54-76</td>
</tr>
<tr>
<td>No. 8</td>
<td>35-57</td>
</tr>
<tr>
<td>No. 30</td>
<td>17-29</td>
</tr>
<tr>
<td>No. 50</td>
<td>10-18</td>
</tr>
<tr>
<td>No. 100</td>
<td>3-10</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-6.5</td>
</tr>
</tbody>
</table>

E. Grading “D”
a. The course aggregate shall consist of crushed gravel, crushed granite, crushed slag, crushed quartzite or crushed gneiss. Other crushed aggregate may be used provided it has the following chemical, physical, and performance characteristics for Type I, Type II or Type III aggregate:

1. Type I

   Silica Dioxide content – minimum of 40%
   Calcium carbonate content – maximum of 32%

   The coarse aggregate shall contain a minimum of 50% by weight of the original sample of acid insoluble residues that are coarser than the No. 100 sieve when tested in accordance with ASTM D 3042.

   The British Pendulum number (BPN) shall not be less than 30 when tested in accordance with AASHTO T 278 after nine hours of accelerated polishing of the aggregate using the British Wheel in accordance with AASHTO T 279.

2. Type II

   Silica Dioxide content – minimum of 30%

   The coarse aggregate shall contain a minimum of 35% by weight of the original sample of acid insoluble residues that are coarser than the No. 100 sieve when tested in accordance with ASTM D 3042.

   The British Pendulum number (BPN) shall not be less than 30 when tested in accordance with AASHTO T 278 after nine hours of accelerated polishing of the aggregate using the British Wheel in accordance with AASHTO T 279.

   In addition to the above requirements, the aggregate shall have met the pre-approval of the Tennessee Department of Transportation, Division of Materials and Tests.
3. Type III (for roads with current ADT of 35,000 or less)

The coarse aggregate shall contain a minimum of 25% by weight of the original sample of acid insoluble residues that are coarser than the No. 100 sieve when tested in accordance with ASTM D 3042.

The British Pendulum number (BPN) shall not be less than 25 when tested in accordance with AASHTO T 278 after nine hours of accelerated polishing of the aggregate using the British Wheel in accordance with AASHTO T 279.

In addition to the above requirements, the aggregate shall have met the pre-approval of the Tennessee Department of Transportation, Division of Materials and Tests.

b. The fine aggregate shall consist of natural sand or sand manufactured from gravel, slag, or from crushed stone aggregate meeting the physical and chemical requirements listed above. The use of carbonate rocks such as limestone and dolomite or other aggregates tending to polish under traffic will not be permitted in the coarse aggregate and will be permitted only to the extent specified herein in the fine aggregate.

F. Grading E.

1. When grading “E” is to be used as a surface for traffic lanes, the mineral aggregate shall be composed of not less than 50%, nor more than 80% crushed limestone, and not more than 50% or not less than 20% natural sand, slag sand, sand manufactured from gravel or other approved non-skid aggregates, or any combination of these materials, except as herein specified.

2. The sand percentage on the job mix formula shall be in the range of 20-50 percent. However, if needed to meet or improve the specified design criteria, the limestone and sand percentage may be altered by the numerical value of 5 percent from the percentage shown by the Contractor on the original job mix formula.

3. When grading “E” is used for surfacing of shoulders or other non-traffic lane construction, the mineral aggregate may be composed entirely of limestone including Size No. 10 (screenings) and manufactured sand, but in no case shall the mineral aggregate for this construction consist of less than 50% limestone.
G. The specified mineral aggregate and asphalt cement shall be combined in such proportions as to produce mixtures within the following master composition limits.

<table>
<thead>
<tr>
<th>Grading</th>
<th>Combined Mineral Aggregate</th>
<th>Asphalt Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;D&quot;</td>
<td>93.0-94.7</td>
<td>5.3-7.0</td>
</tr>
<tr>
<td>&quot;E&quot;</td>
<td>90.3-92.7</td>
<td>7.3-9.7</td>
</tr>
</tbody>
</table>

- If grading “E” is used as a roadway surface mix, the above proportions shall be changed to 93.0-95.5 and 4.5-7.0 for mineral aggregate and asphalt cement respectively.

H. In addition to the other requirements of these specifications the composition of the mineral aggregate shall be such that when combined with the required amount of bitumen the resultant mixture shall have:

<table>
<thead>
<tr>
<th>Mix</th>
<th>Min. Stability Lbf *</th>
<th>Void Content *</th>
<th>Flow (0.01 inch)</th>
<th>Min. % VMA *</th>
<th>Dust-Asphalt Ratio **</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;D&quot;</td>
<td>2000</td>
<td>3-5.5</td>
<td>8-16</td>
<td>14</td>
<td>0.6-1.2</td>
</tr>
<tr>
<td>&quot;E&quot;</td>
<td>2000</td>
<td>3-5.5</td>
<td>8-16</td>
<td>14</td>
<td>-</td>
</tr>
</tbody>
</table>

* Tested in accordance with AASHTO T 245 with 75 blows with the hammer on each end of the test specimen, using a Marshall Mechanical Compactor.

** The dust to asphalt ratio is the percent of the total aggregate sample that passes the 200 mesh sieve as determined by AASHTO T 11 divided by the percent asphalt in the total mix.

PART 3 – EQUIPMENT

3.1 MINERAL AGGREGATE BASE

A. Stationary Mixing Plant.
The mixing unit shall be an approved twin-shaft pugmill capable of producing a constant, uniform mixture. The mixer shall be equipped with a truck-loading hopper of sufficient size with a gate which will prevent segregation of the material when dumped into the truck. A spray bar capable of assuring an even wetting of the aggregate shall be mounted at the entrance of or above the pugmill. The flow of water through the spray bar shall be controlled by a meter, valve or other approved type of regulating device to maintain uniform moisture content in the mixer. A separate quick operating on-and-off device shall be required. The mixing plant shall be equipped with adjustable mechanical feeders for each size material capable of regulating a constant, uniform flow of material.

B. Equipment shall include one or more rollers of a type and sufficient weight to obtain the required density and seal the surface of the base course.
3.2 HOT MIX ASPHALT PAVING

A. Bituminous Mixing Plant
Sufficient storage space shall be provided for each size aggregate. The different sizes shall be kept separated until they have been delivered to the cold elevator or belt feeding the dryer. The storage yard shall be maintained neat and orderly and the separate stockpiles shall be readily accessible for sampling.

B. Equipment for preparation of bituminous material.
Tanks for the storage of bituminous material shall be equipped to heat and hold the material at the required temperatures. The circulating system for the bituminous material shall be designed to assure proper and continuous circulation during the operating period.

C. Feeders for Dryer.
1. Separate feeders shall be provided for each size aggregate, and each size shall be fed onto the belt going to the dryer by mechanical feeders with separate adjustable gates. The feeders shall be capable of delivering the separate aggregates onto the belt in proper proportions.

2. Adequate means shall be provided to assure a constant and uniform flow of material from each bin. Bins containing fine aggregate shall be equipped with vibrators if necessary.

3. The Contractor will not be permitted to blend or mix different aggregates or different sizes of the same aggregates with clam shells, bulldozers, high lifts or similar equipment.

4. The aggregate shall be fed uniformly into the dryer so that a uniform production and uniform temperature may be obtained.

D. Dryer.
The plant shall include a dryer or dryers which agitate the aggregate continuously during the heating and drying process; it shall be capable of heating and drying all aggregates to the temperature required, and shall be capable of supplying the mixing unit continuously at its operating capacity. Dryers shall be constructed and operated so that aggregates will not be contaminated with unburned fuel.

E. Screens.
1. Plant screens, capable of screening all aggregates to the specified sizes and proportions and having normal capacities in excess of full capacity of the mixer, shall be provided.

2. A consistent carry-over, but not to exceed 20%, will be allowed on any screen. If any bin contains more than 20% of material which is undersized for that bin, the bin shall be emptied and correction of the cause for such condition shall be made.

3. Approved scalping screens shall be required on all dryer-drum mixing plants, but additional screens will not be required.
F. Bins. The plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be arranged to assure separate and adequate storage of appropriate fractions of the mineral aggregates. Each bin shall be provided with overflow pipes of such size and at such location as to prevent backing up of material into other compartments or bins. Each compartment shall be provided with an outlet gate constructed so that when closed there shall be no leakage. The gates shall be cut off quickly and completely. The bins shall be constructed to provide adequate and convenient approved facilities for obtaining representative samples of aggregate from the full flow of each compartment. These bins shall no be required in an approved Dryer-Drum Mixing Plant. When mineral filler is used, separate dry storage shall be provided and the plant shall be equipped to uniformly and accurately feed the filler into the mixer.

G. Bituminous control unit. Satisfactory means, either by weighing or metering, shall be provided to obtain the proper amount of bituminous material in the mix within the tolerance specified. Means shall be provided for checking the quantity of rate of flow of bituminous material into the mixer.

H. Thermometric equipment.  
1. An armored thermometer of adequate range in temperature reading shall be fixed in the bituminous feedline at a suitable location near the charging valve at the mixer unit.  
2. An approved thermometric instrument shall be placed at the discharge chute of the dryer as to register automatically or indicate the temperature of the heated aggregates.  
3. The plant shall be equipped with an approved automatic temperature recording and regulating apparatus for control of the temperature of the aggregates.

I. Dust Collector.  
The plant shall be equipped with a dust collector constructed to uniformly waste or return to the dried aggregate all or any part of the material collected.

J. Surge and Storage Systems.  
1. Surge or Storage systems may be used at the option of the Contractor.  
2. The surge and storage system shall be of such design that there is no appreciable difference between material being discharged from the silo and material being discharged directly from the pugmill.
3. The surge and storage silos must be equipped with low and high mix level indicators. The low level indicator shall be placed at a location on the silo that has been predetermined to prevent segregation of the mix.

4. The conveyor system used with the surge or storage silos shall be arranged in such a manner that samples of the mix or dry material may be conveniently taken from the pugmill.

5. Storage silos shall be closed, insulated and heated in such a manner that localized heating does not occur. The storage bin shall be capable of being sealed to prevent oxidation of the mixture. Surge silos shall be equipped with a rain cover capable of preventing water from entering the mix in the silo.

6. Any bituminous mix which is damaged in any way by the use of a surge or storage system will be rejected.

K. Requirement for Batching Plants.

1. Plant Scales.
Dial scales shall be provided for weighing of all aggregates and mineral filler, in the suspended weight box. Dial scales shall be of a standard make and of sufficient size that the numerals on the dial can be read at a distance of 25 feet. The dials shall be of the compounding type having a full complement of index pointers. The value of the graduation of scales used in weighing amounts of aggregates less than 5,000 pounds shall not be greater than five pounds; amounts of aggregates from 5,000 to 10,000 pounds shall not be greater than 10 pounds; amounts of aggregates in excess of 10,000 pounds shall not be greater than 0.1% of the capacity of the scales. All dial scales shall be so located that they will be in plain view of the operator at all times. When bituminous material is measured by weight, the asphalt weigh bucket shall be equipped with a separate dial scale with a minimum graduation not greater than two pounds. All dial scales shall be accurate within a tolerance of 0.5%. Each installation of scales shall be provided with 10 standard 50-pound weights meeting the requirements of the U.S. Bureau of Standards for calibrating and testing weighing equipment.

2. Weigh box or hopper.
The equipment shall include a means for accurately weighing each size of aggregate and mineral filler in a weigh box or hopper suspended on scales. The weigh box or hopper shall be of ample size to hold a full batch without hand raking or running over. The gate shall close tightly so that no material is allowed to leak into the mixer while a batch is being weighed.
3. Bituminous control.
The bituminous material bucket shall be a non-tilting type. The length of
the discharge opening or spray bar shall be not less than three-fourths
the length of the mixer and it shall discharge directly into the mixture; the
bituminous material bucket, its discharge valve or valves, and spray bar
shall be adequately heated. Steam jackets, if used, shall be efficiently
drainable and all connections shall be so constructed that they will not
interfere with the efficient operation of the bituminous scales. The
capacity of the bituminous material bucket shall be at least 15% in excess
of the weight of bituminous material required in any batch. The plant shall
have an adequately heated quick-acting, non-drip, charging valve located
directly over the bituminous material bucket. When the bituminous
material is metered, the indicator dial shall have a capacity of at least
15% in excess of the quantity of bituminous material used in a batch. The
meter indicator dial shall have a scale with divisions measuring in gallons
equivalent to a weight sensitivity of 0.04% of the total batch weight. The
meter shall be accurate within a tolerance of 0.5%. The controls shall be
so constructed that they may be locked at any dial setting and will
automatically reset to that reading after the addition of bituminous
material to each batch. The dial shall be in full view of the mixer operator.
The flow of bituminous material shall be automatically controlled so that it
will begin when the dry-mixing period is over. All of the bituminous
material required for one batch shall be discharged in not more than 15
seconds after the flow has started. The size and spacing of the spray
bar openings shall provide a uniform application of bituminous material
the fill length of the mixer. The section of the bituminous line between the
charging valve and the spray bar shall be provided with a valve, and the
spray bar shall be provided with a valve and outlet for checking the meter
when a metering device is substituted for a bituminous material bucket.

The batch mixer shall be an approved twin pugmill type, steam or hot oil
jacketed, and shall be capable of producing a uniform mixture within the
job mix tolerances. The mixer shall be so constructed as to prevent
leakage of its contents. It shall be equipped with a sufficient number of
paddles or blades set in the “run around” order and operated at such
speed as to produce a properly and uniformly mixed batch. The depth of
the material in the pugmill shall not be above the tips of the paddles. If
not enclosed, the mixer box shall be equipped with a dust hood to prevent
loss of dust.
5. Control of mixing time.
The mixer shall be equipped with an accurate time lock to control the operations of a complete mixing cycle. It shall lock the weigh box gate after the charging of the mixer until the closing of the mixer gate at the completion of the cycle. It shall lock the bituminous material bucket throughout the dry-mixing period and shall lock the mixer gate throughout the dry and wet-mixing periods. The control of timing shall be flexible and capable of being set at intervals of five (5) seconds or less throughout a total cycle of up to three (3) minutes. A mechanical batch counter shall be installed as a part of the timing device and shall be so designed as to register only batches that have been mixed for the full time interval.

The plant shall be equipped with a scale observer’s house. The house shall be mounted on or near the weigh platform and shall be so situated that the aggregate and asphalt scales, asphalt thermometer, and pyrometer are plainly visible from within the house.

L. Requirements for Continuous Mixing Plants

1. Aggregate proportioning.
The plant shall have a feeder mounted under each compartment bin. Each compartment bin shall have an accurately controlled individual gate to form an orifice for measuring volumetrically the material drawn from each compartment. Bins shall be equipped with adequate tell-tale devices to indicate the position of the aggregates in the bins at the lower quarter points.

The feeding orifice shall be rectangular with one dimension adjustable by positive mechanical means provided with a lock. Indicators shall be provided for each gate to show the respective gate opening in inches.

Mineral filler shall be fed into the mixer continuously and uniformly in the proportion set out in the formula for the job mix.

2. Weight calibration of aggregate feed.
The plant shall be equipped with an approved revolution counter in satisfactory working condition. The plant shall include a means for calibration of gate openings by weighing test samples. Provision shall be made so that materials fed out of individual orifices may be bypassed to individual test boxes. The plants shall be equipped to handle conveniently individual test samples weighing not less than 200 pounds. Accurate scales shall be provided by the Contractor to weigh such test samples.
3. Synchronization of aggregate feed and bituminous material feed. Satisfactory means shall be provided to afford positive interlocking control between the flow of aggregate from the bins and the flow of bituminous material from the meter or other proportioning device. This control shall be accomplished by mechanical means or by any other positive method.

The plant shall include a continuous mixer of an approved twin pugmill type, adequately heated and capable of producing a uniform mixture within the job mix tolerances. The paddles shall be adjustable for angular position on the shafts and reversible to retard the flow of mix. The mixer shall have a manufacturer’s plate giving the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge. Charts shall be provided showing the rate of feed of aggregate per minute for the aggregate being used. Determination of mixing time shall be by the weight method.

5. Surge hopper.
The mixer shall be equipped with a discharge hopper with dump gates that will permit rapid and complete discharge of the mixture and of such size and design that no segregation of the mixture occurs.

6. Platform truck scales.
Platform truck scales shall be a standard brand of scales with a sufficient rated capacity to weight the maximum gross load to which they will be subjected. In no instance shall truck scales by used to measure weights in excess of the manufacturer’s rated capacity. The manufacturer’s rated capacity shall be clearly posted on the scale manufacturer’s plate and in the shelter provided for the weighman.

The recording mechanism of the scale shall be housed in a suitable shelter. The scale shall be accurate within a tolerance of 0.5% and the value of the minimum graduation shall not be greater the 100 pounds.

M. Requirements for Dryer-Drum Mixing Plants.

1. Control of Aggregate.
The aggregates shall be stockpiled and handled so as to prevent any significant amount of segregation, contamination or degradation.

Each aggregate shall have a separate feeder that has a positive feed, which can be easily and accurately calibrated. The plant shall have a flow indicator and an audible warning device on each feeder to assure a constant and uniform flow of aggregate from each bin onto the belt. Mineral filler, if required, shall be fed into the mixer continuously and uniformly in the proportion set out in the formula for the job mix.
2. Synchronization of Aggregate Feed and Bituminous Material Feed. Satisfactory means shall be provided to afford a positive interlocking control between cold aggregate feed and asphalt. The control setting for the asphalt flow will be based on the dry weight of the aggregate. There must be an acceptable method provided for the proportioning asphalt flow as variations in aggregate flow take place. A metering system will be provided to measure the flow of asphalt into the drum and an approved method of checking and calibrating the metering system shall be located in the control house. An automatic interlock system will be provided that will shut off the asphalt flow and the burner when the aggregate flow ceases.

3. Temperature Control. Dryer-Drum Mixing Plants shall be equipped with a recording pyrometer or other approved thermometric instrument sensitive to a rate of temperature change of not less the 10 degrees per minute. The system shall be equipped with automatic burner controls and shall provide for temperature sensing of the bituminous mixture at discharge from the drum.

4. Scales and Metering Systems The Contractor shall be required to furnish weights and charts for checking the accuracy of the belt scales and the bituminous metering system. The scales and meters shall have accuracy within a tolerance of 0.5%.

The belt scale, which weighs the combined aggregate, shall be in accordance with the National Institute of Standards and Technology Handbook 44.

5. Sampling Devices. There shall be an approved method provided for sampling individual cold feeds and sequential sampling of aggregate and asphalt under full-scale production. The sampling device and procedures used shall be such that the normal operation with not be interrupted.

6. Platform Scales. The Contractor shall make certified platform scales available for checking the asphalt metering system and for weighing or checking loads of asphalt mix.

7. Silos or Surge Bins Surge or storage silos shall meet the requirements of subsection 3.2(J).

8. Aggregate Feed. Aggregate shall be proportioned by feeding each size aggregate from a separate cold bin. The belt that delivers the aggregate shall have a load cell capable of registering the amount of flow from each individual bin on a readout in the control office; or the aggregate shall be proportioned by a linear system based on measured RPM or each feeder belt at a constant gate opening to feed aggregate at a predetermined rate that is set in the
control office and which has a readout in the control office. The rate of feed as determined from the bin settings shall agree with the load cell on the collection belt feeding the dryer within a tolerance of ±10%. In the event that the predetermined tolerance is exceeded, an alarm shall sound, and if corrections are not made with sixty (60) seconds, the plant shall automatically shut down. The aggregate feed system shall employ computer-controlled adjustments to automatically produce mix of the correct proportions over the entire range of production rates of the plant.

9. Electronic Data Retention.
The computer system and automatic weighing system shall include means to retain all electronic data during electrical power failures.

N. Hauling Equipment
Trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds which have been thinly coated with a minimum amount of paraffin oil, hydrated-lime solution or other approved material to prevent the mixture from adhering to the beds. Each truck shall be covered immediately after loading at the plant with a cover of canvas or other suitable material. The covers shall be of sufficient size to protect the mixture from the weather. The cover shall lap down along the sides and rear of the truck bed a minimum of six (6) inches and be secured by tie downs at a maximum of five (5) foot spacing along the sides and rear of the truck bed. When necessary, so that the mixture will be delivered on the road at the specified temperature, truck beds shall be insulated and covers shall be securely fastened.

O. Pressure Distributor.
The distributor shall be so designed, equipped, maintained and operated that bituminous material at even heat may be applied uniformly on variable widths of surface at readily determined and controlled rates for 0.2 to 0.5 gallons per square yard. Distributor equipment shall include a tachometer, pressure gauges, accurate volume measuring devices, a calibrated tank, and a thermometer for measuring the temperature of the material in the tank. Distributors shall be equipped with a power unit for the pump, and full circulation spray bars adjustable laterally and vertically.

P. Bituminous Pavers.
1. Bituminous pavers shall be self-contained, power propelled units provided with an activated screed, equipped to be heated, and capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the specified typical section and thickness shown on the plans.

2. Materials for shoulders less than eight (8) feet in width and similar construction may be placed by means of approved mechanical spreading equipment.
3. The screed or strike-off assembly shall produce effectively a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture.

4. All asphalt paving machines shall be equipped with automatic grade and slope controls. Both the grade and slope controls shall be in working order at all times, except that, in the event of mechanical failure of the automatic controls, the Contractor will be permitted to finish the day’s work using manual controls but will not be allowed to resume work the following day until both the grade and slope controls are in first class working order.

Q. Rollers.

1. Rollers shall be self-propelled and of steel-wheel, pneumatic tire, and/or vibratory type. Rollers shall be in good condition, capable of reversing without backlash and shall be operated at speeds slow enough to avoid displacement of the bituminous mixture.

2. Rollers shall be equipped with a device for moistening and cleaning the wheels as required.

3. The steel-wheel roller shall weigh a minimum of eight tons and may be either a three-wheel or tandem type.

4. The pneumatic tire rollers shall have a minimum contact pressure of 85 psi. The roller shall contain two axles upon which are mounted not less than seven pneumatic-tire wheels in a manner so that the rear set of tires will not track the front set. The axles shall be mounted in a rigid frame provided with a loading platform or body suitable for ballast loading. The tires shall be uniformly inflated. A combination roller (pneumatic and steel wheel combination) may be substituted for a pneumatic tire roller.

5. The use of vibratory rollers will be permitted.

PART 4 – EXECUTION

4.1 MINERAL AGGREGATE BASE

A. The Contractor shall be required to use a stationary mixing plant. The base coarse material and water shall be mixed in an approved stationary mixing plant as described in section 3.1. Water shall be added during the mixing operation in the amount necessary to provide a moisture content satisfactory to meet the grading requirements. All material fed into the plant shall travel the full length of the pugmill.

B. After mixing, material for each layer of base shall be transported to the job site while it contains the proper moisture content, and shall be spread to the required thickness and cross section by means of an approved mechanical spreader.
C. If the required compacted depth of the base course exceeds six (6) inches, the base shall be constructed in two or more layers of approximate equal thickness. The maximum compacted thickness of any one layer shall not exceed six (6) inches.

D. Immediately following spreading, the base material shall be shaped to the required degree of uniformity and smoothness and compacted to the required density prior to any appreciable evaporation of surface moisture.

E. For density testing purposes each completed layer will be divided into lots of approximately 10,000 square yards. Five density tests will be performed on each lot and the results averaged.

F. The average density of each lot, unless otherwise specified, shall be not less than 95% of maximum density determined in accordance with AASHTO T99, Method D. Further, no individual test shall be less than 92% of maximum density.

G. If the density is not obtained, the material shall be reworked or replaced in order to comply with the density requirement.

H. The surface of each layer shall be so constructed that the aggregates become firmly keyed and a uniform texture produced and shall be maintained in that condition until final acceptance of the project. Any irregularities that develop shall be corrected by loosening the material at those places and adding or removing material as required.

I. Approved distributors shall be used to apply water uniformly over the base materials during compaction in sufficient quantity for proper compaction.

J. The thickness of the completed base shall be in reasonably close conformity to the thickness shown on the Plans (±\(\frac{1}{4}\))

4.2 PRIME COAT

A. Seasonal and temperature limitations for applying bituminous prime coat shall conform to the same requirements as those specified for the succeeding stage of construction. The prime may be applied to a surface that is slightly damp, but never to a wet surface.

B. Bituminous material consisting of Cut-back asphalt, conforming to ASTM D 2027 shall be applied to the width of the section to be primed by means of a pressure distributor at a uniform, continuous spread of 0.2 to 0.5 gallons per square yard. The Contractor shall protect all structures and concrete surfaces from the bituminous material during the construction.

C. If after the bituminous material has been applied, it fails to penetrate before the time that the roadway must be used by traffic, dry cover material shall be spread at a rate of 8 to 12 pounds per square yard to prevent damage to the primed surface.
4.3 TACK COAT

A. Bituminous material consisting of emulsified asphalt conforming to ASTM D 977 shall be applied with the pressure distributor at a rate of 0.05 gallon of residual bitumen per square yard. If the bituminous material is to be placed upon a milled surface, the rate of application shall be 0.20 gallon of residual bitumen per square yard.

B. The tacked surface shall be allowed to dry until it is in a proper condition to receive the next course. Tack coat shall be applied only so far in advance of the paving operations as is necessary to obtain this proper condition of tackiness. The Contractor shall protect the tack coat from damage until the next course is placed.

4.4 HOT-MIX ASPHALT PAVING

A. Weather Limitations.

Bituminous plant mix may be placed on properly constructed and accepted subgrade or previously applied layers provided the following conditions are met:

1. The subgrade and the surface upon which bituminous plant mix is placed shall be free of excessive moisture.

2. The bituminous plant mix shall be placed in accordance with the temperature limitations of the following table and only when weather conditions otherwise permit the pavement to be properly placed, compacted and finished.

<table>
<thead>
<tr>
<th>Compacted Thickness</th>
<th>Minimum Placement Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unmodified</td>
</tr>
<tr>
<td>≤ 1.5&quot;</td>
<td>45°F</td>
</tr>
<tr>
<td>&gt;1.5&quot;</td>
<td>40°F</td>
</tr>
</tbody>
</table>

3. Unless otherwise permitted in writing, no bituminous plant mix, with a compacted thickness of 1.5 inches or less, shall be placed between November 30 and April 1; and further, no bituminous plant mix, with a compacted thickness greater than 1.5 inches shall be placed between December 15 and March 16. Where permission is granted to place mix during the above prohibited periods, the temperature requirements in #2 above shall be increased 10°F.

B. Condition of Existing Surface.

1. When bituminous mixes are to be placed upon an existing concrete pavement, with or without a bituminous overlay, all excess bituminous material shall be removed from joints and cracks. Sections of existing pavement that are broken and pumping under traffic shall be removed. Pavement where blowups have occurred at joints or cracks shall be
removed to provide a minimum opening of one (1) foot for the full width of
the pavement.

2. When the bituminous mixture is to be placed upon an existing bituminous
pavement, any areas containing excess bitumen and any failures in the
existing surface and base shall be removed.

3. The Contractor shall properly adjust all manholes and catch basin frames,
associated with the storm sewer system, to the finished grades of the
pavement. Unless otherwise specified, such adjustments shall be made
without additional compensation. The respective Utility Owner(s) shall
properly adjust all utility manholes, utility valve covers and like structures,
to the finished grades of the pavement, unless otherwise stipulated by the
Plans.

4. Unsatisfactory subgrade material encountered when existing pavement is
removed shall be removed and replaced with approved material.
Openings left by the pavement and base removal shall be filled to the full
depth of the existing pavement and compacted in layers not to exceed
three (3) inches in thickness.

5. Contact surface of curbing, gutters, manholes, and other structures shall
be painted with a thin, uniform coating of bituminous material prior to the
mixture being placed against them.

C. The bituminous materials for hot mixes shall be heated to the required mixing
temperature, ±10°F as shown on the Job Mix formula, in a manner that will avoid
local overheating and provide a continuous supply of bituminous material to the
mixer at a uniform temperature at all times.

D. Unless otherwise specified, the aggregate for hot mixes shall be dried and
heated so as to produce a completed mix of uniform temperature of ±20°F of the
temperature shown on the Job Mix Formula. Flames used for drying and heating
shall be properly adjusted to avoid damage to the aggregate and to avoid soot on
the aggregate.

On all plants requiring screens, the hot dried aggregate shall be screened into
two or more fractions as specified. The separated fractions shall then be
conveyed into separate compartments ready for batching and mixing with
bituminous material.

E. Mixing.
1. The dried aggregates shall be combined within the mixer in the amount of
each fraction of aggregates required to meet the Job Mix formula. The
bituminous material shall be measured and introduced into the mixer in
the amount specified by the job mix formula.

2. The materials shall be mixed until a complete and uniform coating of the
particles and a thorough distribution of the bituminous material throughout
the aggregate is secured.
3. The temperature of the completed mixture, made with aggregates containing absorbed moisture which causes foaming or boiling in the completed mix shall be not less than 225°F. The temperature of the mix when it is discharged from the mixer shall not deviate from that shown on the Job Mix Formula by more than ±20°F.

4. The temperature for grading A-S shall be between 225°F and 275°F.

5. Unless otherwise specified the temperature of all other bituminous pavement mixture shall be as designated on the Job Mix Formula.

F. Use of Surge or Storage Silos.

1. The surge of storage system shall conform to the requirements of this specification.

2. Hours of plant operation, whether for storage or direct shipment to the road, shall be limited to reasonable working hours in order that normal inspection of plant operations may be performed.

3. Bituminous mixtures placed in a surge silo must be removed on the same day in which it is stored.

4. Bituminous mixtures Gradings A, A-S, and B may be stored for up to 48 hours and Gradings B-M, B-M2, D, and E for up to 96 hours in a storage silo provided the following requirements are met:
   a. An approved silicone additive shall be added to the asphalt cement for mixes to be stored beyond the day of mixing
   b. The stored bituminous mixture shall be kept sealed at all time during storage.
   c. The storage silo shall be filled to at least 90% of capacity.

5. Samples of the stored material will be taken following the period of storage.

6. Material stored will be subject to the temperature, segregation, and laying requirements as required for unstored plant production.

7. Excessive segregation, lumpiness, or stiffness of the mix shall be sufficient cause for rejection by the ENGINEER.

8. The Surge and Storage silos shall be located in a position that enables the top of the truckload to be visible to the load operator during the loading operation.
G. Spreading and finishing.

1. Bituminous mixtures shall be delivered and spread on the roadway in ample time to secure thorough compaction during daylight hours.

2. The temperature of the mixture at the time of depositing in the paver hopper shall be ±20° F of the temperature shown on the Job Mix Formula.

3. The mixture shall be placed upon an approved surface, spread and struck off to the established line, grade and elevation by means of approved asphalt paving machine(s). Echelon or full-width paving may be permitted where plant production is capable of supplying the paver so that a constant forward speed can be maintained.

4. Where multi-course pavements are placed, the longitudinal joint in one layer shall offset that in the layer immediately before by approximately one (1) foot; however, the joint in the top layer shall be at the center-line of the pavement if the roadway comprises two lanes of width.

5. Plant production and paving operations shall be so coordinated that there is constant forward movement of the pavers. Repetitive interruptions or stopping of the paver shall be cause to stop work until the cause of the stoppage is corrected. If the paver must be stopped for a significant period of time, a joint shall be constructed and the paver moved from the roadway before the bituminous mixture has cooled sufficiently to prevent proper compaction. If the bituminous mixture is permitted to cool to the extent that the required density cannot be obtained, the mixture shall be removed and replaced at the Contractor's expense.

6. Automatic screed controls utilizing either the string line or ski type grade reference system will be required on all work regardless of the paver width. The string line reference system may be required on new construction. In the event the base has been finished with equipment having automatic grade control or the Contractor demonstrates that an alternate method of spreading and finishing will result in a satisfactory riding surface, the ski type reference system may be used. The Engineer may at any time require the use of a string line reference system if the use of the string line will result in a superior riding surface. When the string line system is required on a multi-course pavement, it shall be used on at least two courses exclusive of the surface course.

The string line reference system shall consist of suitable wire or twine supported by approved devices, which will be compatible with the type of automatic paver control system used. The string line and supports shall be capable of maintaining the line and grade designated by the plans at the point of support while withstanding the tensioning necessary to prevent sag in excess of one-fourth inch between supports spaced fifty feet apart.
The cost of erecting and maintaining the string line reference system shall be included in the unit price bid for other items of construction.

7. Where the ski type system is used, the ski shall have the maximum practical length and in no case shall it be less than forty (40) feet in length. Pavement lanes previously placed with automatic controls or to form grade may serve as longitudinal control reference for placing adjacent lanes by utilizing a ski or joint matching shoe.

8. Automatic screed controls will not be required on sections of projects where service connections and other conditions interfere with their efficient operation.

9. On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, the mixture shall be taken from the hopper of the spreading machine and shall be distributed immediately into place by means of suitable shovels and other tools and spread with rakes and lutes in a uniformly loose layer of such depth as will result in a completed course having the required thickness.

H. Compaction.

1. After the bituminous mixture has been spread, struck off, and surface irregularities adjusted, it shall be thoroughly compacted. The method employed must be capable of compacting the mixture to the specified density while it is in a workable condition.

2. Each paving train shall consist of a minimum of three (3) rollers as specified in this specification. The intermediate roller in each train shall be a pneumatic type.

The minimum number of rollers listed above may be reduced to one roller of either the steel-wheel or vibratory type on a project containing less than 10,000 square yards of bituminous pavement.

3. Unless otherwise directed, rolling shall begin at the low side and proceed longitudinally parallel to the road centerline. When paving in echelon or abutting a previously placed lane, the longitudinal joint shall be rolled first, followed by the regular rolling procedure. When paving in echelon, rollers shall not compact within six (6) inches of an edge where an adjacent lane is to be placed. Rollers shall move in a slow uniform speed with the drive wheels nearer the paver and shall be kept as nearly as possible in continuous operation. Rolling shall continue until all roller marks are eliminated. Rollers shall not park on the bituminous pavement.

I. Density Requirements.

1. The density (bulk specific gravity) determination for a compacted asphalt mixture shall be performed in accordance with AASHTO T-166, Method A or C.
Any base or surface course that test below the minimum density shall be corrected until the density of the area is equal to or above minimum before it can be used to determine the average density of the lot. No successive layer, where applicable, shall be placed until the area has been corrected.

2. For density testing purposes, the pavement shall be divided into lots of 10,000 square yards, except for gradings “A”, “B-M”, and “B-M2” which shall be divided into lots of approximately 5,000 square yards. Five density tests shall be performed in each lot and the average results compared with the requirements below.

3. If the average density of the lot does not conform to the requirements stated herein, or if an individual test value does not meet the requirements stated herein, the Contractor shall continue his compactive effort until the required density is obtained.

4. Along forms, curbs, headers, walls and other places not accessible to the rollers, the mixture shall be compacted thoroughly with hot hand tampers, smoothing irons, or mechanical tampers. On depressed areas, a trench roller may be used to compact the mix.

5. Bituminous Plant Mix Base, Gradings “A”, “B-M” and “B-M2”. An average of 92% of theoretical density shall be required. No individual density test shall be less than 90% of theoretical density.

6. Bituminous Plant Mix Base, Grading “CW”. An average of 88% of theoretical density shall be required. No individual density test shall be less than 85% of theoretical density.

7. Asphaltic Concrete Surface Course, Gradings “D” and “E”. An average of 92% of maximum theoretical density with no individual test falling below 90% of maximum theoretical density.

8. Density requirements shall be waived on Bituminous Plant Mix Base Grading “A-S”. However, a system of compaction for roadway pavements shall be employed. When placing bituminous Plant Mix Base grading “A-S”, the intermediate roller (pneumatic tire) specified previously may be replaced by a steel wheel type if irreparable damage to the pavement is occurring.

J. Test Strips.
Test strips shall be required for all “A”, “B-M”, “B-M2”, “CW”, “D”, and “E” mixes to establish rolling patterns, to calibrate nuclear gauges, and to verify that the base course or surface course meets the density requirements of the specifications.
Construction of the test strip shall be as follows:

1. The base course or other pavement course upon which a test strip is constructed shall have been approved prior to the construction of the test strip.

2. Each test strip shall be constructed with approved bituminous mixture and shall remain in place as a section of the completed work. Each test strip shall be one paver-width wide and have an area of at least 400 square yards and shall be the depth specified for the pavement course concerned.

3. Compaction of the test strip shall commence immediately after placement of the bituminous mixture and be continuous and uniform over the entire test strip.

   The compaction of the test strip shall be continued until no appreciable increase in density (1.0 lbs/C.F.) as measured with the nuclear gauge can be obtained by additional roller coverage. The roller coverage necessary to obtain this maximum density shall be used as the rolling pattern for the remainder of the project.

4. The Contractor will take cores on the test strip at ten randomly selected locations. Cores shall not be taken within two feet of the longitudinal edges for calibration or determining average densities. The Contractor shall then have the densities of the cores determined and these values shall be used in calibrating the nuclear gauge and to verify that the average density of the test strip meets the density requirements of the specifications.

5. In the event the density of the asphaltic concrete in the test strip does not meet specification requirements, the Contractor shall make whatever changes necessary to obtain the specified density.

K. Placing of the bituminous paving shall be as continuous as possible. Rollers shall not pass over the unprotected end of a freshly laid mixture. Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. A brush coat of bituminous material shall be used on contact surfaces of transverse joints just before additional mixture is placed against the previously rolled material.

L. Surface Requirements.

1. The surface shall be tested with a 12 foot straightedge applied parallel to the centerline of the pavement. The deviation of the surface form the
testing edge of the straightedge shall not exceed that specified below for the respective types of bituminous construction.

<table>
<thead>
<tr>
<th>Mix</th>
<th>Acceptable Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>“A” – “A-S”</td>
<td>0.5”</td>
</tr>
<tr>
<td>“B-M”, “B-M2”, “CW”</td>
<td>0.375”</td>
</tr>
<tr>
<td>“D”</td>
<td>0.25”</td>
</tr>
</tbody>
</table>

2. The transverse slopes of tilted pavements shall be tested with a stringline and string level applied at right angles to the centerline of the pavement, and the per cent slope, when computed for the full width of the pavement shall not deviate more than five-tenths of one percentage point from that specified on the Plans.

3. The crown in crowned pavements shall be tested with a stringline applied at right angles to the centerline of the pavement and the crown shall not deviate more than one-half inch from that specified on the Plans.

4. Deviations greater than the specified tolerances shall be corrected by methods best suited for the purpose. Pavement that cannot be corrected to comply with the specified tolerances shall be removed and replaced at the Contractor's expense.

END OF SECTION 32 12 16 – HOT-MIX ASPHALT PAVING
PART 1 GENERAL

1.01 SCOPE
   A. This section includes the requirements for constructing sub-base and related aggregate surfacing.

1.02 RELATED WORK SPECIFIED ELSEWHERE
   A. Section 31 2313: Subgrade Preparation

1.03 REFERENCE STANDARDS
   A. Unless otherwise specified, the Work for this Section shall conform to the applicable portions of the following Standard Specifications:
      1. ASTM – American Society of Testing and Materials
      2. AASHTO – American Association of State Highways and Transportation Officials
      3. TDOT – Tennessee Department of Transportation, 2006 Standard Specifications for Road and Bridge Construction

1.04 ALLOWABLE TOLERANCES
   A. The finished surface shall be shaped to conform to plan grade and cross section within a tolerance of two (2) inches of the finished grade shown on the Plans.

1.05 TEST REPORTS
   A. The testing lab shall provide the ENGINEER with two (2) certified copies of the test results of the thickness of the compacted aggregate.
   B. The core drilling, testing for thickness and the certification of the test results shall be performed by a testing laboratory approved by the ENGINEER.

1.06 STOCKPILING AGGREGATE
   A. Aggregate shall be deposited in stockpiles in such a manner that the material may be removed from the stockpile by methods which will provide aggregate having a uniform gradation.
   B. Stockpiling of aggregate, in excess of four (4) feet in depth, on the completed subbase or aggregate surface will not be permitted, except with the approval of the ENGINEER.
1.07 ENVIRONMENTAL REQUIREMENTS

A. Comply with the requirements for aggregate base or surfacing installations due to outside ambient air temperatures specified under Article 3.09 of this Section.

PART 2 PRODUCTS

2.01 DENSE-GRADED AGGREGATE FOR GRAVEL ROADWAYS

A. For gravel roadways, the dense-graded aggregate gradation shall conform to ASTM D693 and to Type A Aggregate, Grading D, as specified in TDOT, Section 903.05.

B. The gradation for dense-graded aggregate used for gravel surfacing for final site restoration and stabilization shall conform to ASTM D693 and to Type B Aggregate, Grading D as specified in TDOT Section 903.05.

2.02 WATER

A. Water used for compaction and dust control shall be reasonably clean and free from substances injurious to the finished product.

B. Water from sources approved by the Tennessee State Department of Public Health as potable may be used.

PART 3 EXECUTION

3.01 EXCAVATION VERIFICATION

A. Prior to the placing of any aggregate material, examine the excavation for the grades, lines, and levels required to receive the new Work.

B. Ascertain that all excavation and compacted subgrades or subbases are adequate to receive the new Work.

C. Correct all defects and deficiencies before proceeding with the Work.

3.02 SUBGRADE CONDITIONS

A. Prior to the placing of any aggregate material, examine the subgrade or subbase to ascertain that it is adequate to receive the aggregate to be placed. If the subgrade or subbase remains wet after all surface water has been removed, the ENGINEER may require further mechanical stabilization of the subgrade at no additional cost to the OWNER.

3.03 EXISTING BASE

A. Prior to the placing of any aggregate material for surfacing, examine the existing base for grade and condition to receive the new Work.
B. Ascertain that the base is adequately compacted to receive the aggregate surfacing to be installed.

C. Correct all defects and deficiencies before proceeding with the Work.

3.04 EXISTING IMPROVEMENTS

A. Investigate and verify locations of existing improvements, including structures, to which the new Work will be in contact.

B. Necessary adjustment in line and grade, to align the new Work with the existing improvements must be approved by the ENGINEER, prior to any changes.

3.05 PREPARATION OF SUBGRADE OR SUBBASE

A. The subgrade or subbase shall be rough graded to the cross section indicated on the Plans, and shall be thoroughly compacted prior to the placing of the aggregate material.

3.06 INSTALLATION- GENERAL

A. The width, thickness, and type of aggregate materials shall be indicated on the Plans or as directed by the ENGINEER.

B. No aggregate material shall be placed until the subgrade, or subbase, or existing aggregate surface has been approved by the ENGINEER.

3.07 AGGREGATE SURFACE COURSE

A. Where the base for the new aggregate surface course is an existing aggregate surface, the existing surfacing, shall be either graded or scarified and graded to remove irregularities and to provide a bond between the old and new surfaces.

B. The aggregate surface course shall be placed by a mechanical spreader or other approved means, in uniform layers to such a depth that when compacted, the course will have the thickness shown on the Plans.

C. The depth of the surface course, when compacted, shall not exceed six (6) inches, unless otherwise specified on the Plans or directed by the ENGINEER.

1. The aggregate shall be a uniform mixture when placed on the prepared base.

2. It shall be uniformly spread and then trimmed with a road grade, trimmer or other approved means until the surface is free from waves and irregularities.

3. The trimming shall be alternated by rolling with a pneumatic-tired or tamping type roller.
4. The entire operation shall continue until the surface course is compacted to at least 98% of maximum dry unit weight, as determined by ASTM Standard D698. The moisture content of the aggregate surface materials should be controlled to within 1 percent of optimum moisture content as determined by ASTM Standard D698.

D. When the operation is completed, the surface course shall conform to the required lines, grades and cross sections.

E. The optimum moisture content shall be maintained until the prescribed unit weight is obtained and each layer shall be compacted until the maximum unit weight is attained before placing the succeeding layer.

F. When approved by the ENGINEER, additional water may be applied by an approved means, to the aggregate to aid in the compaction and shaping of the material.

3.08 MAINTENANCE DURING CONSTRUCTION

A. The aggregate surface shall be continuously maintained in a smooth and firm condition during all phases of the construction operation.

B. The CONTRACTOR, at his expense, shall provide additional materials needed to fill depressions or bind the aggregate.

3.09 TEMPERATURE LIMITATIONS

A. Aggregate materials shall not be placed when there are indication that mixtures may become frozen before the maximum unit weight is obtained.

B. In no case shall the aggregate be placed on a frozen subgrade or base course unless otherwise directed by the ENGINEER.

3.10 CLEANUP

A. Immediately following the compacting of the surface course and where noted on the Plans, the voids on both side of the aggregate course shall be backfilled with sound earth of topsoil quality.

B. The backfill shall be compacted, leveled and left in a neat, workmanlike condition.

C. At a seasonally correct time, approved by the ENGINEER, the disturbed area shall be raked, having topsoil placed thereon, fertilized and seeded per the requirements of Section 32 9219, Seeding, or the area shall be stabilized with surface gravel, as noted on the Plans, immediately following completion of trench backfilling.

3.11 OPENING AGGREGATE SURFACED ROADS

A. The ENGINEER reserves the right to open the aggregate surfacing to traffic at any time during construction.
3.12 TESTING

A. During the course of the Work, the ENGINEER may require testing for compaction or density and for thickness of material. The testing required shall be performed by a testing laboratory acceptable to the OWNER and approved by the ENGINEER. The cost for testing and coring shall be at the expense of the CONTRACTOR.

B. When thickness tests are done, a minimum of one depth (thickness) measurement will be made every 10,000 square feet. The location of the depth measurement will be at the discretion of the ENGINEER.

C. The maximum dry unit weight when used as a measure of compaction or density of soils shall be understood to mean the maximum dry unit weight per cubic foot as determined by ASTM D698.

D. Perform one-in-place density test every 5,000 square feet per lift.

3.13 DEFECTIVE WORK

A. Thickness:

1. Measurements of aggregate base and/or surface course thickness will be made to the nearest ¼ inch.
   
   a. Depths may be ½ inch less than the thickness indicated on the Plans provided that the average of all measurements taken at regular intervals shall be equal to or greater than the specified thickness.
   
   b. In determining the average in place thickness, measurements which are more than ½ inch in excess of the thickness indicated on the Plans will be considered as the specified thickness plus ½ inch.

2. Locations of the depth measurements will be as specified herein unless otherwise directed by the ENGINEER.

3. Sections found to be deficient in depth shall be corrected by the CONTRACTOR using methods approved by the ENGINEER.

B. Weight:

1. When the aggregate is measured by weight in Tons, the pay weights for aggregates will be the scale weight of the material, including admixtures, unless the moisture content is more than six (6) percent.
2. Moisture tests will be made at the start of weighing operations and at any time thereafter when construction operations, weather conditions or any other cause may result in a change in the moisture content of the material.

   a. If the tests indicate a moisture content in excess of six (6) percent, the excess over six (6) percent will be deducted from the scale weight of the aggregate until such time as moisture tests indicate that the moisture content of the material is not more than six (6) percent.

END OF SECTION 32 15 00 – AGGREGATE SURFACING
PART 1 - GENERAL

1.1 SECTION INCLUDES

A. General: Cast-in-place concrete, including formwork, reinforcing, mix design, placement procedures, and finishes.

B. Cast-in-place concrete includes the following:

1. Concrete Curb and Combined Curb and Gutter.
2. Footings
3. Sidewalks
4. Pavement

1.2 REFERENCES

A. American Society for Testing and Materials

1. ASTM A 82-90a: Specification for Steel Wire, Plain, for Concrete Reinforcement.
3. ASTM A 615 -90: Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
4. ASTM C 31 -90: Test Method of Making and Curing Concrete Test Specimens in the Field.
5. ASTM C 33-90: Specification for Concrete Aggregates.
7. ASTM C 42 -90a: Methods of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
10. ASTM C 172-90: Practice for Sampling Freshly Mixed Concrete.
11. ASTM C 173.78: Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
12. ASTM C 231: Test Method of Air Content of fr eshly Mixed Concrete by the Pressure Method.
19. ASTM E 154-88: Methods of Testing Materials for Use as Vapor Barriers Under Concrete Slabs and as Ground Cover in Crawl Spaces.

B. American Concrete Institute (ACI)

1. ACI 301-89: Specifications for Structural Concrete for Buildings.
2. ACI 305R-89: Hot Weather Concreting.
4. ACI 309R-87: Guide for Consolidation of Concrete.
5. ACI 318-89: Building Code Requirements for Reinforced Concrete.

C. American Association of State Highway and Transportation Officials (AASHTO)

AASHTO M 182-89: Burlap Cloth Made from Jute or Kenaf.

D. U.S. Army Corps of Engineers (Waterways Experiment Station, Vicksburg, MS 39205)


E. American Concrete Institute

ACI Manual of Concrete Practice

F. Concrete Reinforcing Steel Institute Manual of Standard Practice

1.4 SUBMITTALS

A. Product data for proprietary materials and items, including reinforcement and forming accessories, admixtures, patching compounds, waterstops, joint systems, curing compounds and others if requested by the Engineer.

B. Shop drawings for reinforcement detailing fabricating, bending, and placing concrete reinforcement. Comply with ACI 315 “Manual of Standard Practice for Detailing Reinforced Concrete Structures” showing bar schedules, stirrup spacing, bent bar diagrams, and arrangement of concrete reinforcement. Include special reinforcing required for openings through concrete structures.

C. Laboratory test reports for concrete materials and mix design test.

D. Material certificates in lieu of material laboratory test reports. Material certificates shall be signed by manufacturer and CONTRACTOR, certifying that each material item complies with or exceeds specified requirements. Provide certification from admixture manufacturers that chloride content complies with specification requirements.
E. Submit pigment manufacturer’s color chart for color selection; indicated pigment number and required dosage rate. Submittals are for general color selection and may vary somewhat from concrete finished in field according to Specifications.

1.5 QUALITY ASSURANCE

A. Codes and Standards: Comply with provisions of the following codes, specifications, and standards, except where more stringent requirements are shown or specified:

1. American Concrete Institute (ACI) 301, “Specifications for Structural Concrete for Buildings.”
2. ACI 318, “Building Code Requirements for Reinforced Concrete.”

B. Concrete Testing Service: Engage a testing agency to perform material evaluation tests and to design concrete mixes.

C. Materials and installed work may require testing and retesting at any time during progress of Work. Tests, including retesting of rejected materials for installed Work, shall be done at CONTRACTOR’S expense.

D. Obtain each material from the same source and maintain high degree of consistency in workmanship throughout the Project.

E. Installer Qualifications: Concrete work shall be finished by firm with five years experience with work of similar scope and quality.

F. Minor variations in appearance of colored concrete, which are similar to natural variations in color and appearance of unpigmented concrete, are acceptable.

PART 2 – PRODUCTS

2.1 FORMWORK

A. Forms for Exposed Finish Concrete: Plywood, metal, metal-framed plywood faced, or other acceptable type materials to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints.

1. Use overlaid plywood complying with U.S. Product Standard PS-1 “A-C or B-B High Density Overlaid Concrete Form,” Class I.

B. Forms for Unexposed Finish Concrete: Plywood, lumber, metal, or another acceptable material. Provide lumber dressed on at least two edges and one side for tight fit.
C. Forms for Cylindrical Columns and Supports: Metal, glass-fiber-reinforced plastic, or paper or fiber tubes that will produce smooth surfaces without joint indications. Provide units with sufficient wall thickness to resist wet concrete loads without deformation.

D. Form Release Agent: Provide commercial formulation form release agent with a maximum of 350 g/L volatile organic compounds (VOCs) that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

E. Form Ties: Factory-fabricated, adjustable-length, removable or snap-off metal form ties designed to prevent form deflection and to prevent spalling of concrete upon removal. Provide units that will leave no metal closer than 1-1/2 inches to the plane of the exposed concrete surface.

   1. Provide ties that, when removed, will leave holes no larger than 1 inch in diameter in the concrete surface.

2.2 REINFORCING MATERIALS

A. Reinforcing Bars ASTM A 615, Grade 60, deformed.

B. Steel Wire: ASTM A 82, plain, cold-drawn steel.


D. Supports for Reinforcement: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place. Use wire bar-type supports complying with CRSI specifications.

   1. For slabs-on-grade, use supports with sand plates or horizontal runners where base material will not support chair legs.

2.3 CONCRETE MATERIALS

A. Portland Cement: ASTM C 150, Type I.

B. Fly Ash: ASTM C 618, Type F.

C. Normal-Weight Aggregates: ASTM C 33 and as specified. Provide aggregates from a single source for exposed concrete.

   For exposed exterior surfaces, do not use fine or coarse aggregates that contain substances that cause spalling.

D. Water: Potable
E. Fiber Reinforcement: Polypropylene fibers engineered and designed for secondary reinforcement of concrete slabs, complying with ASTM C 1116, Type III, not less than 3/4 inch long.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Gilco fibers, Cormix Construction Chemicals.
   b. Fiberstrand 100, Euclid Chemical Co.
   e. Polystrand, Metalcrete Industries.

F. Admixtures, General: If used, provide concrete admixtures that contain not more than 0.1 percent chloride ions.

G. Air-Entraining Admixture: ASTM C 260, certified by manufacturer to be compatible with other required admixtures.

1. Products: Subject to compliance with requirements, provide the following:
   a. Airtite, Cormix Construction Chemicals.
   b. Air-Mix or Perma-Air, Euclid Chemical Co.
   c. Darex AEA or Daravair, W.R. Grace & Co.
   d. MB-VR or Micro-Air, Master Builders, Inc.
   e. Sealtight AEA, W.R. Meadows, Inc.
   f. Sika AER, Sika Corp.

H. Water-Reducing Admixture: ASTM C 494, Type A.

1. Products: Subject to compliance with requirements, provide one of the following:
   b. PSI N, Cormix Construction Chemicals.
   c. Eucon WR-75, Euclid Chemical Co.
   d. WRDA, W.R. Grace & Co.
   e. Pozzolith Normal or Polyheed, Master Builders, Inc.
   f. Plastocrete 161, Sika Corp.

I. High-Range Water-Reducing Admixture: ASTM C 494, Type F or Type G.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Cormix 200, Cormix Construction Chemicals.
   b. Eucon 37, Euclid Chemical Co.
   c. WRDA 19 or Daracem, W.R. Grace & Co.
   d. Rheobuild or Polyheed, Master Builders, Inc.
   e. Sikament 300, Sika Corp.
J. Water-Reducing, Accelerating Admixture: ASTM C 494, Type E.

   1. Products: Subject to compliance with requirements, provide one of the following:

      a. Q-Set, Conspec Marketing & Manufacturing Co.
      b. Lubricon NCA, Cormix Construction Chemicals.
      c. Accelguard 80, Euclid Chemical Co.
      e. Pozzutec 20, Master Builders, Inc.
      f. Accel-Set, Metalcrete Industries.

K. Water-Reducing, Retarding Admixture: ASTM C494, Type D.

   1. Products: Subject to compliance with requirements, provide one of the following:

      a. PSI -R Plus, Cormix Construction Chemicals.
      b. Eucon Retarder 75, Euclid Chemical Co.
      c. Daratard-17, W.R. Grace & Co.
      d. Pozzolith R, Master Builders, Inc.
      e. Protard, Prokete Industries, Inc.
      f. Plastiment, Sika Corporation.

2.4 RELATED MATERIALS

A. Waterstops: If indicated, provide flat, dumbbell-type or centerbulb-type waterstops at construction joints and other joints as indicated. Size to suit joints.

B. Polyvinyl Chloride Waterstops: Corps of Engineers CRD-C 572.

   1. Manufacturers: Subject to compliance with requirements, provide products of one of the following:

      a. The Burke Co.
      b. Greenstreak Plastic Products Co.
      c. W.R. Meadows, Inc.

C. Vapor Retarder: Provide vapor retarder that is resistant to deterioration when tested according to ASTM E 154, as follows:

   1. Polyethylene sheet not less than 8 mils thick.

D. Nonslip Aggregate Finish: Provide fused aluminum oxide granules or crushed emery as the abrasive aggregate for a nonslip finish, with emery aggregate containing not less than 25 percent ferric oxide. Use material that is factory-graded, packaged, rustproof, nonglazing and unaffected by freezing, moisture, and cleaning materials.
E. Absorptive Cover: Burlap cloth made from jute or kenaf, weighing approximately 9 oz. Per sq. yd., complying with AASHTO M 182, Class 2.

F. Moisture-retaining Cover: One of the following, complying with ASTM C 171.

1. Waterproof paper.
2. Polyethylene film.
3. Polyethylene-coated burlap.

G. Liquid Membrane-Forming Curing compound: Liquid-type membrane-forming curing compound complying with ASTM C 309, Type I Class A. Moisture loss not more than 0.55 kg/sq. meter when applied at 200 sq. ft./gal.

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Sealco 309, Cormix Construction chemicals.
   c. Eucocure, Euclid Chemical Co.
   d. Masturkure, Master Builders, Inc.
   e. CS-309, W. R. Meadows, Inc.
   f. Kure-N-Seal, Sonneborn-Chemrex.

H. Water-Based Acrylic Membrane Curing Compound: ASTM C 309, Type I, Class B.

1. Provide material that has a maximum volatile organic compound (VOC) rating of 350 g/L.
2. Products: Subject to compliance with requirements, provide one of the following:
   a. Sealco - VOC, Cormix Construction Chemicals.
   b. Aqua-Cure, Euclid Chemical Co.
   c. Dress & Seal WB, L&M Construction Chemicals, Inc.
   d. Masterkure 100W, Master Builders, Inc.
   e. Vocomp-20, W.R. Meadows, Inc.

I. Evaporation Control: Monomolecular film-forming compound applied to exposed concrete slab surfaces for temporary protection from rapid moisture loss.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Eucobar, Euclid Chemical Co.
   b. E-Con, L7M Construction Chemicals, Inc.
   c. Confilm, Master Builders, Inc.

J. Underlayment Compound: Free-flowing, self-leveling, pumpable, cement-based compound for applications from 1 inch thick to feathered edges.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Polyvinyl Acetate (Interior Only):
      1. Euco Weld, Euclid Chemical Co.
      2. Everweld, L&M Construction Chemicals, Inc.
   b. Acrylic or Styrene Butadiene:
      1. SBR Latex, Euclid Chemical Co.
      3. Everbond, L&M Construction Chemicals, Inc.
      5. Sonocrete, Sonneborn-Chemrex.

L. Epoxy Adhesive: ASTM C 881, two-component material suitable for use on dry or damp surfaces. Provide material type, grade, and class to suit Project requirements.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Euco Epoxy System #452 or #620, Euclid Chemical Co.
      b. Epabond, L&M Construction Chemicals, Inc.
      c. Concresive Standard Liquid, Master Builders, Inc.
      e. Sikadur 32 Hi-Mod, Sika Corp.

M. Water and Chloride Repellant - PROSOCO Saltguard WB.

2.6 PROPORTIONING AND DESIGNING MIXES

A. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301. For the trial batch method, use an independent testing agency for preparing and reporting proposed mix designs.

   1. Limit use of fly ash to not exceed 25 percent of cement content by weight.

B. Submit written reports to the Engineer for each proposed mix for each class of concrete at least 15 days prior to start of Work.

C. Design mixes to provide normal weight concrete with the following properties as indicated on drawings and schedules:

   1. 5000-psi, 28-day compressive strength; water-cement ratio, 0.40 maximum (non-air-entrained), 0.43 maximum (air-entrained).
2. 4000-psi, 28-day compressive strength; water-cement ratio, 0.49 maximum (non-air-entrained), 0.52 maximum (air-entrained).

D. Water-Cement Ratio: Provide concrete for following conditions with maximum water-cement (W/C) ratios as follows:

1. Subjected to freezing and thawing: W/C 0.45.

E. Slump Limits: Proportion and design mixes to result in concrete slump at point of placement as follows:

1. Ramps, slabs, and sloping surfaces: Not more than 3 inches.
2. Reinforced foundation systems: Not less than 1 inch and not more than 3 inches.
3. Concrete containing high-range water-reducing admixture (superplasticizer): Not more than 8 inches after adding admixture to site-verified 2-to-3-inch slump concrete.
4. Caissons: Not less than 3 inches and not more than 6 inches.
5. Other concrete: Not more than 4 inches.

F. Adjustment to Concrete Mixes: Mix design adjustments may be requested by CONTRACTOR when characteristics of materials, job conditions, weather, test results, or other circumstances warrant, as accepted by Architect. Laboratory test data for revised mix design and strength results must be submitted to and accepted by the Engineer before using in Work.

G. Fiber Reinforcement: Add at manufacturer’s recommended rate but not less than 1.5 lb per cu. yd.

H. Pigments: Mix in accordance with manufacturer’s instructions. Mix until pigments are uniformly dispersed throughout mixture and disintegrating bags, if used, have disintegrated.

2.7 ADMIXTURES

A. General: The use of admixtures other than air-entraining admixture is the CONTRACTOR’S option and responsibility if it can be demonstrated that such use will improve placement and workability of the concrete without detriment to strength, durability and other specified qualities. Types, manufacture, proportions, etc., of proposed admixtures to be used in any mix shall be part of the mix designs and/or laboratory test data submitted for acceptance by the Architect.

B. Water-reducing admixture or high-range water-reducing admixture (superplasticizer) may be used in concrete, as required, for placement and workability.

C. Accelerating admixture may be used in concrete slabs placed at ambient temperatures below 50 degrees F (10 deg C).
D. High-range water-reducing admixture may be used in pumped concrete, concrete required to be watertight, and concrete with water-cement ratios below 0.50.

E. Use air-entraining admixture in exterior exposed concrete unless otherwise indicated. Add air-entraining admixture at manufacturer’s prescribed rate to result in concrete at point of placement having total air content with a tolerance of plus or minus 1-1/2 percent within the following limits:

1. Concrete structures and slabs exposed to freezing and thawing, deicer chemicals, or hydraulic pressure:
   a. 4.5 percent (moderate exposure): 6.0 percent (severe exposure) for 1-inch maximum aggregate.
   b. 5.0 percent (moderate exposure): 6.0 percent (severe exposure) for 3/4-inch maximum aggregate.

F. Use admixtures for water reduction and set accelerating or retarding in strict compliance with manufacturer’s directions.

2.8 CONCRETE MIXING

A. Job-Site Mixing: Mix concrete materials in appropriate drum-type batch machine mixer. For mixers of 1 cubic yard or smaller capacity, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released. For mixers of capacity larger than 1 cu. yd., increase minimum 1-1/2 minutes of mixing time by 15 seconds for each additional cu. yd.

1. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mix type, mix time, quantity, and amount of water introduced.

B. Ready-Mixed Concrete: Comply with requirements of ASTM C 94, and as specified.

1. When air temperature is between 85 deg F (30 deg C) and 90 deg F (32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes, and when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.
PART 3 – EXECUTION

3.1 GENERAL

A. Coordinate the installation of joint materials, vapor retarder/barrier, and other related materials with placement of forms and reinforcing steel.

3.2 FORMS

A. General: Design, erect, support, brace, and maintain formwork to support vertical, lateral, static, and dynamic loads that might be applied until concrete structure can support such loads. Construct formwork so concrete members and structures are of correct size, shape, alignment, elevation, and position. Maintain formwork construction tolerances and surface irregularities complying with the following ACE 347 limits.

1. Provide Class A tolerances for concrete surfaces exposed to view.
2. Provide Class C tolerances for other concrete surfaces.

B. Construct form to sizes, shapes, lines, and dimensions shown and to obtain accurate alignment, location, grades, level, and plumb work in finished structures. Provide for openings, offsets, signage, keyways, recesses, chamfers, blocking, screeds, bulkheads, anchorages and inserts, and other features required in the Work. Use selected materials to obtain required finishes. Solidly butt joints and provide backup at joints to prevent cement paste from leaking.

C. Fabricate Forms for easy removal without hammering or prying against concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces where slope is too steep to place concrete with bottom forms only. Kerf wood inserts for forming keyways, reglets, recesses, and the like for easy removal.

D. Provide temporary openings for clean-outs and inspections where interior area of formwork is inaccessible before and during concrete placement. Securely brace temporary openings and set tightly to forms to prevent losing concrete mortar. Locate temporary openings in forms at inconspicuous locations.

E. Chamfer exposed corners and edges if indicated, using wood, metal, PVC, or rubber chamfer strips fabricated to produce uniform smooth lines and tight edge joints.

F. Provisions for other Trades: Provide openings in concrete formwork to accommodate work of other trades. Determine size and location of openings, recesses, and chases from trades providing such items. Accurately place and securely support items built into forms.

G. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, or other debris just before placing concrete. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
3.3 VAPORETARDER/BARRIER INSTALLATION

A. General: Place vapor retarder/barrier sheeting in position with longest dimension parallel with direction of pour.

C. Lap joints 6 inches and seal with manufacturer’s recommended mastic or pressure-sensitive tape.

3.4 PLACING REINFORCEMENT

A. General: Comply with Concrete Reinforcing Steel Institute’s recommended practice for “Placing Reinforcing Bars,” for details and methods of reinforcement placement and supports and as specified.

1. Avoiding cutting or puncturing vapor retarder/barrier during reinforcement placement and concreting operations. Repair damages before placing concrete.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other materials that reduce or destroy bond with concrete.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcing by metal chairs, runners, bolster, spacers, and hangers.

D. Place reinforcement to maintain minimum coverage as indicated for concrete protection. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.

E. Install welded wire fabric in lengths as long as practicable. Lap adjoining pieces at least one full mesh and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

F. Supports for Reinforcing Bars: Use corrosion-resistant types at locations in contact with exposed surfaces.

3.5 JOINTS

A. Expansion and Construction Joints: Locate and install expansion and construction joints so they do not impair strength or appearance of the structure.

B. Provide keyways at least 1-1/2 inches deep in construction joints in walls and slabs and between walls and footings. Bulkheads designed and accepted for this purpose may be used for slabs.
C. Place construction joints perpendicular to main reinforcement. Continue reinforcement across construction joints except as indicated otherwise. Do not continue reinforcement through sides of strip placements.

D. Use bonding agent on existing concrete surfaces that will be joined with fresh concrete.

E. Waterstops: Provide waterstops in construction joints as indicated. Install waterstops to form continuous diaphragm in each joint. Support and protect exposed waterstops during progress of Work. Field-fabricate joints in waterstops according to manufacturer’s printed instructions.

F. Isolation Joints in Slabs-on-Grade: construct isolation joints in slabs-on-grade at points of contact between slabs-on-grade and vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.

G. Contraction (Control) Joints in Slabs-on-Grade: Construct contraction joints in slabs-on-grade at 5’ intervals to form panels of patterns as shown. Use inserts 1/4-inch-wide by one-fourth of slab depth. The joint filler shall be a joint filler stop of closed cell polyethylene foam backer rod of sufficient size to provide a tight seal. The backer rod shall be installed in a saw cut joint to prevent the sealant from flowing to the bottom. The backer rod shall be compatible with the joint sealant to act as a bond breaker.

H. Expansion Joints: Construct expansion joints at 20’ O.C. for concrete walk and low flow swale and in the center of concrete sidewalk. See joint plan for parking areas and drives. All expansion joints shall include 18” long smooth coated #4 bars spaced on 12” centers at the midpoint of the slab depth.

I. Expansion Joint Filler: The filler shall meet the requirements of AASHTO M213, bituminous preformed joint fillers, and be full depth.

J. Joint Sealer: Sealant shall meet the requirements of Tennessee Department of Transportation Standard Specification Section 905.05. The sealant shall have a minimum of 75 percent extensibility at a temperature range of -50° F to 200° F.

3.6 INSTALLING EMBEDDED ITEMS

A. General: Set and build into formwork anchorage devices and other embedded items required for other work that is attached to or supported by cast-in-place concrete. Use setting drawings, diagrams, instructions, and directions provided by suppliers of items to be attached.

B. Forms for Slabs: Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and contours in finished surfaces. Provide and secure units to support screed strips using strike-off templates or compacting-type screeds.
3.7 PREPARING FORM SURFACES

A. General: coat contact surfaces of forms with an approve, nonresidual, low-VOC, form-coating compound before placing reinforcement.

B. Do not allow excess form-coating material to accumulate in forms or come into contact with in-place concrete surfaces against which fresh concrete will be placed. Apply according to manufacturer’s instructions.

   1. Coat steel forms with a nonstaining, rust-preventative material. Rust-stained steel formwork is not acceptable.

3.8 CONCRETE PLACEMENT

A. Inspection: Before placing concrete, formwork, reinforcing steel, and items to be embedded or cast in shall be inspected.


C. Deposit concrete continuously or in layers of such thickness that no new concrete will be placed on concrete that has hardened sufficiently to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as specified. Deposit concrete to avoid segregation at its final location.

D. Placing Concrete in Forms: Deposit concrete in horizontal layers no deeper than 24 inches and in a manner to avoid inclined construction joints. Where placement consists of several layers, place each layer while preceding layer is still plastic to avoid cold joints.

   1. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping. Use equipment and procedures for consolidation of concrete complying with ACI 309.

   2. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations no farther than the visible effectiveness of the machine. Place vibrators to rapidly penetrate placed layer and at least into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mix to segregate.
E. Placing Concrete Slabs: Deposit and consolidate concrete slabs in a continuous operation, within limits of construction joints, until completing placement of a panel or section.

1. Consolidate concrete during placement operations so that concrete is thoroughly worked around reinforcement, other embedded items and into corners.
2. Bring slab surfaces to correct level with a straightedge and strike off. Use bull floats or darbies to smooth surface free of humps or hollows. Do not disturb slab surfaces prior to beginning finishing operations.
3. Maintain reinforcing in proper position on chairs during concrete placement.

F. Cold-Weather Placement: Comply with provisions of ACI 306. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures. When air temperature has fallen to or is expected to fall below 40 deg F (4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.

1. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
2. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise accepted in mix designs.

G. Hot-Weather Placement: When hot weather conditions exist that would impair quality and strength of concrete, place concrete complying with ACI 305 and as specified.

1. Cool ingredients before mixing to maintain concrete temperature at time of placement to below 90 deg F (32 deg C). Mixing water may be chilled or chopped ice may used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is CONTRACTOR’S option.
2. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedding in concrete.
3. Fog spray forms, reinforcing steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without puddles or dry areas.
4. Use water-reducing retarding admixture when required by high temperatures, low humidity, or other adverse placing conditions, as acceptable to Architect.
3.9 FINISHING FORMED SURFACES

A. Rough-Formed Finish: Provide a rough-formed finish on formed concrete surfaces not exposed to view in the finished Work or concealed by other construction. This is the concrete surface having texture imparted by form-facing material use, with tie holes and defective areas repaired and patched, and fins and other projections exceeding 1/4 inch in height rubbed down or chipped off.

B. Smooth-Formed finish: Provide a smooth-formed finish on formed concrete surfaces exposed to view or to be covered with a coating material applied directly to concrete, or a covering material applied directly to concrete, such as waterproofing, dampproofing, painting or another similar system. This is an as-cast concrete surface obtained with selected form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch defective areas with fins and other projections completely removed and smoothed.

C. Smooth-rubbed Finish: Provide smooth-rubbed finish on exposed-to-view round column and pier surfaces that have received smooth-formed finish treatment not later than 1 day after form removal.

1. Moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.

D. Grout-Cleaned Finish: Provide grout-cleaned finish as an alternate option to smooth-rubbed finish.

1. Combine one-part Portland cement to one and one-half parts fine sand by volume, and a 50:50 mixture of acrylic or styrene butadiene-based bonding admixture and water to form the consistency of thick paint. Blend standard Portland cement and white Portland cement in amounts determined by trial patches so that final color of dry grout will match adjacent surfaces.

2. Thoroughly wet concrete surfaces, apply grout to coat surfaces, and fill small holes. Remove excess grout by scraping and rubbing with clean burlap. Keep damp by fog spray for at least 36 hours after rubbing.

E. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike-off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.
3.10 MONOLITHIC SLAB FINISHES

A. Scratch Finish: Apply scratch finish to monolithic slab surfaces to receive mortar setting beds for tile and other bonded applied cementitious flooring material, and where indicated.

1. After placing slabs, finish surface to tolerances of F(F) 15 (floor flatness) and F(L) 13 (floor levelness) measured according to ASTM E 1155. Slope surfaces uniformly to drains where required. After leveling, roughen surface before final set with stiff brushes, brooms, or rakes.

B. Float Finish: Apply float finish to monolithic slab surfaces to receive trowel finish and other finishes as specified: slab surfaces to be covered with membrane or elastic waterproofing, membrane or elastic roofing, or sand-bed terrazzo: and where indicated.

1. After screeding, consolidating, and leveling concrete slabs, do not work surface until ready for floating. Begin floating, using float blades or float shoes only, when surface water has disappeared, or when concrete has stiffened sufficiently to permit operation of power-driven floats, or both. Consolidate surface with power-driven floats or by hand-floating if area is small or inaccessible to power units. Finish surfaces to tolerances of F(F) 18 (floor flatness) F(L) 15 (floor levelness) measured according to ASTM E 1155. Cut down high spots and fill low spots. Uniformly slope surfaces to drains. Immediately after leveling, refloat surface to a uniform, smooth, granular texture.

C. Trowel Finish: Apply a trowel finish to monolithic slab surfaces exposed to view and slab surfaces to be covered with resilient flooring, carpet, ceramic or quarry tile, paint, or another thin film-finish coating system.

1. After floating, begin first trowel-finish operation using a power-driven trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand-troweling operation, free of trowel marks, uniform in texture and appearance, and finish surfaces to tolerances of F(F) 20 (floor flatness) and F(L) 17 (floor levelness) measured according to ASTM E 1155. Grind smooth any surface defects that would telegraph through applied floor covering system.

D. Nonslip Broom Finish: Apply a nonslip broom finish to exterior concrete walks, platforms, steps, and ramps, and elsewhere as indicated.

1. Immediately after float finishing, slightly roughen concrete surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate required final finish with Architect before application.
E. Nonslip Aggregate Finish: Apply nonslip aggregate finish to concrete stair treads, platforms, ramps, sloped walks, and where indicated.

1. After completing float finishing and before starting trowel finish, uniformly spread 25 lb of dampened nonslip aggregate per 100 sq. ft. of surface. Tamp aggregate flush with surface using a steel trowel, but do not force below surface. After broadcasting and tamping, apply trowel finishing as specified.

2. After curing, lightly work surface with a steel wire brush or an abrasive stone, and water to expose nonslip aggregate.

3.11 MISCELLANEOUS CONCRETE ITEMS

A. Filling In: Fill in holes and openings left in concrete structures for passage of work by other trades, unless otherwise shown or directed, after work of other trades is in place. Mix, place, and cure concrete as specified to blend with in-place construction. Provide other miscellaneous concrete filling shown or required to complete Work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

C. Equipment Bases and Foundations: Provide machine and equipment Bases and foundations as shown on drawings. Set anchor bolts for machines and equipment to template at correct elevations, complying with diagrams or templates of manufacturer furnishing machines and equipment.

D. Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items. Cast-in safety inserts and accessories as shown on drawings. Screed, tamp, and trowel-finish concrete surfaces.

3.12 CONCRETE CURING AND PROTECTION

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. In hot, dry, and windy weather protect concrete from rapid moisture loss before and during finishing operations with an evaporation-control material. Apply according to manufacturer’s instructions after screeding and bull floating, but before power floating and troweling.

B. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting, keep continuously moist for not less than 7 days.

C. Curing Methods: Cure concrete by curing compound, by moist curing, by moisture-retaining cover curing, or by combining these methods, as specified.
D. Provide moisture curing by the following methods:
   1. Keep concrete surface continuously wet by covering with water.
   2. Use continuous water-fog spray.
   2. Cover concrete surface with specified absorptive cover, thoroughly saturate cover with water, and keep continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges, with a 4-inch lap over adjacent absorptive covers.

E. Provide moisture curing by the following methods:
   1. Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width with sides and ends lapped at least 3 inches and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

F. Apply curing compound on exposed interior slabs and on exterior slabs, walks, and curbs as follows:
   1. Apply curing compound to concrete slabs as soon as final finishing operations are complete (within 2 hours and after surface water sheen has disappeared). Apply uniformly in continuous operation by power spray or roller according to manufacturer’s directions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.
   2. Use membrane curing compounds that will not affect surfaces to be covered with finish materials applied directly to concrete.
   3. All exterior concrete shall be treated with ProSoCo “Saltguard WB” as per the manufacturer’s recommendations.

G. Curing Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces, by moist curing with forms are removed. If forms are removed, continue curing by methods specified above, as applicable.

H. Curing Unformed Surfaces: Cure unformed surfaces, including slabs, floor topping, and other flat surfaces, by applying the appropriate curing method.
   1. Final cure concrete surfaces to receive finish flooring with a moisture-retaining cover, unless otherwise directed.
I. Curing Compound for Colored Concrete: Curing compound shall comply with ASTM C309 and be approved by pigment manufacturer for use with colored concrete. Provide {W-1000 Clear Cure & Seal} {Color Seal II tinted to match colored concrete and} manufactured by Davis Colors or equal.

1. Colored Concrete: Apply curing compound in accordance with manufacturer’s instructions.

3.13 SHORES AND SUPPORTS

A. General: Comply with ACI 347 for shoring and reshoring.

B. Remove shores and re-shores in a planned sequence to avoid damage to partially cured concrete. Locate and provide adequate re-shoring to support work without excessive stress of deflection.

C. Keep re-shores in place a minimum of 15 days after placing upper tier, or longer, if required, until concrete has attained its required 28-day strength and heavy loads due to construction operations have been removed.

3.14 REMOVING FORMS

A. General: formwork not supporting weight of concrete, such as sides of beams, walls, columns, and similar parts of the work, may be removed after cumulatively curing at not less than 50 deg F (10 deg C) for 24 hours after placing concrete, provided concrete is sufficiently hard to not be damaged by form-removal operations, and provided curing and protection operations are maintained.

B. Formwork supporting weight of concrete, such as beam soffits, joists, slabs, and other structural elements, may not be removed in less than 14 days or until concrete has attained at least 75 percent of design minimum compressive strength at 28 days. Determine potential compressive strength of in-place concrete by testing field-cured specimens, representative of concrete location or members.

C. Form-facing material may be removed 4 days after placement only if shores and other vertical supports have been arranged to permit removal of form-facing material without loosening or disturbing shores and supports.

3.15 REUSING FORMS

A. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-coating compound as specified for new formwork.

B. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close joints. Align and secure joint to avoid offsets. Do not use patched forms for exposed concrete surfaces.
3.16 CONCRETE SURFACE REPAIRS

A. Patching Defective Areas: Repair and patch defective areas with cement mortar immediately after removing forms.

B. Mix dry-pack mortar, consisting of one-part Portland cement to 2 1/2 parts fine aggregate passing a No. 16 mesh sieve, using only enough water as required for handling and placing.

1. Cut out honeycombs, rock pockets, voids over 1/4 inch in any dimension, and holes left by tie rods and bolts down to solid concrete but in no case to a depth less than 1 inch. Make edges of cuts perpendicular to the concrete surface. Thoroughly clean, dampen with water, and brush-coat the area to be patched with bonding agent. Place patching mortar before bonding agent has dried.

2. For surfaces exposed to view, blend white Portland cement and standard Portland cement so that, when dry, patching mortar will match surrounding color. Provide test areas at inconspicuous location to verify mixture and color match before proceeding with patching. Compact mortar in place and strike-off slightly higher than surrounding surface.

C. Repairing formed Surfaces: Remove and replace concrete having defective surfaces if defects cannot be repaired. Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycomb, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning. Flush out form tie holes and fill with dry-pack mortar or precast cement cone plugs secured in place with bonding agent.

1. Repair concealed formed surfaces, where possible, containing defects that affect the concrete’s durability. If defects cannot be repaired, remove and replace the concrete.

D. Repairing Unformed Surfaces: Test unformed surfaces, such as monolithic slabs, for smoothness and verify surface tolerances specified for each surface and finish. Correct low and high areas as specified. Test unformed surfaces sloped to drain for trueness of slope and smoothness by using a template having the required slope.

1. Repair finished unformed surfaces containing defects that affect the concrete’s durability. Surface defects include crazing and cracks in excess of 0.01-inch-wide or that penetrate to the reinforcement or completely through nonreinforced sections regardless of width, spalling, popouts, honeycombs, rock pockets, and other objectionable conditions.

2. Correct high areas in unformed surfaces by grinding after concrete has cured at least 14 days.
3. Correct low areas in unformed surfaces during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete. Proprietary underlayment compounds may be used.

4. Repair defective areas, except random cracks and single holes not exceeding 1 inch in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose reinforcing steel with at least 3/4-inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials to provide concrete of same type or class as original concrete. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.

E. Repair isolated random cracks and single holes 1 inch or less in diameter by dry-pack method. Groove top of cracks and cut out holes to sound concrete and clean of dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding compound. Place dry-pack before bonding agent has dried. Compact dry-pack mixture in place and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.

F. Perform structural repairs using epoxy adhesive and mortar.

3.17 QUALITY CONTROL TESTING DURING CONSTRUCTION

A. General: The Owner shall employ a testing agency to perform tests.

B. Sampling and testing for quality control during concrete placement shall include the following:

1. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.
   a. Slump: ASTM C 143; one test at point of discharge for each day’s pour of each type of concrete; additional tests when concrete consistency seems to have changed.
   b. Air Content: ASTM C 173, volumetric method for lightweight or normal weight concrete; ASTM C 231, pressure method for normal weight concrete; one for each day’s pour of each type of air-entrained concrete.
   c. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F (4 deg C) and below, when 80 deg F (27 deg C) and above, and one test for each set of compressive-strength specimens.
d. Compression Test Specimen: ASTM C 31; one set of three standard cylinders for each compressive-strength test, unless otherwise directed. Mold and store cylinders for laboratory-cured test specimens, except when field-cured test specimens are required.

e. Compressive-Strength Tests: ASTM C 39; one set for each day’s pour exceeding 5 cu. yd. Plus additional sets for each 50 cubic yards more than the first 25 cubic yards of each concrete class placed in any one day; one specimen tested at 7 days, two specimens tested at 28 days.

2. When frequency of testing will provide fewer than five strength tests for a given class of concrete, conduct testing from at least five randomly selected batches or from each batch if fewer than five are used.

3. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing the in-place concrete.

4. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength and no individual strength test result falls below specified compressive strength by more than 500 psi.

C. Test results shall be reported in writing to the ready-mix producer, and CONTRACTOR within 24 hours after tests. Reports of compressive strength tests shall contain the Project identification name and number, date of concrete placement, name of concrete testing service, concrete type and class, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7-day tests and 28-day tests.

D. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted but shall not be used as the sole basis for acceptance or rejection.

E. Additional Tests: The testing agency shall make additional tests of in-place concrete when test results indicated specified concrete strengths and other characteristics have not been attained in the structure. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed.

END OF SECTION 32 16 13 – CAST-IN PLACE CONCRETE
PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

This work shall consist of furnishing and supplying pavement markings in accordance with these specifications, the latest revision of the “Manual on Uniform Traffic Control Devices” published by the FHWA, and in reasonably close conformity to the lines, dimensions, patterns, locations, and details shown on the plans or established by the Engineer.

1.2 RELATED SECTIONS

A. Section 32 12 16 – Hot-Mix Asphalt Paving

PART 2 – MATERIALS

2.1 PAINT

A. General Requirements: The pigmented binder shall be properly formulated so as to be suitable for application by spray equipment when heated to 123°F maximum and applied on bituminous or Portland cement concrete pavements.

B. Glass Beads shall be the drop-on type, and shall meet the requirements of AASHTO M 247 Type I or Type II, unless otherwise specified.

Beads retained on the No. 20 sieve shall have a minimum of 65% true spheres. Beads passing the No. 20 sieve shall have a minimum of 75% true spheres.

Beads retained on the No. 20 sieve shall have a minimum of 65% true spheres. Beads passing the No. 20 sieve shall have a minimum of 75% true spheres.

C. Characteristic Requirements

1. Pigment content shall be between 58% and 65% by weight. Pigment for white paint shall contain 0.99 Lbs./Gal. Of 94% titanium dioxide. Pigment for yellow paint shall be lead free and contain 0.22 Lb/Gal. Minimum of 94% titanium dioxide.

2. Total non-volatile shall not be less than 76% by weight.

3. Vehicle non-volatile shall not be less than 41% by weight. Vehicle shall be Rohm and Haas E-2706, DOW DT211NA or approved equal.

4. Minimum weight shall not be less than 13.3 Lbs./Gal.

5. The paint viscosity shall be between 78 and 95 Kerb units when tested at 25°C (±1°C).
6. The paint shall dry to a no-track condition in 60 seconds when applied a 15 mil. (±1 mil.) wet film thickness. The dry time shall be checked at ambient temperature and humidity as applied. The paint shall also have a dry through (early washout) requirement of the following: a 15 mil. (±1 mil.) wet film of the candidate paint placed immediately in a humidity chamber maintained at 75°F (±2°F) and 90% (±5%) relative humidity shall have a dry-through time of 30 minutes maximum when tested in accordance with ASTM D 1640 except that the pressure exerted will be the minimum needed to maintain contact between the thumb and film.

7. The paint shall meet the current EPA VOC requirements of 150 grams/L whichever is lower.

8. The pH of the paint shall be a minimum of 9.6.

D. Qualitative Requirements

The finished paint shall meet the following quality requirements:

1. Condition in container: The paint received shall show no livering, skinning, mold growth, corrosion of the container, or hard settling of the pigment. Any settling shall be readily dispersed when stirred by hand with no persistent foaming.

2. Color: The color for white after drying shall be flat white, free from tint, furnishing good opacity and visibility under both daylight and artificial light. For yellow, the color shall closely match chip 33538 of Federal Standard 595.

3. Flexibility: The paint shall show no cracking or flaking when tested on a ½” mandrel in accordance with Federal Specification TT-P-1952B.

4. Dry Opacity: The minimum contract ratio shall be 0.95 when drawn with a 0.005 Bird Applicator.

5. Daylight Reflectance: The daylight directional reflectance of the white paint shall no be less than 85% and not less than 50% for yellow (relative to manganese oxide) when measured in accordance with Federal Test Method No. 1416.6.

6. Bleeding: The paint shall have a minimum bleeding ratio of 0.97 when tested in accordance with Federal Specification TT-9-1952B.

7. Scrub Resistance: The paint shall pass 300 cycles when tested in accordance with ASTM D 2484.

8. Freeze-Thaw Stability: The paint shall show no change in consistency greater than 10% when tested in accordance with Federal Specification TT-P-1952B.
9. **Storage Stability:** When stored at 25°C (±2°C) in a three-quarter filled can for a period of thirty days, the paint shall be in a homogeneous state with no skinning, curdling, hard settling or caking that cannot be readily remixed.

2.2 **THERMOPLASTIC**

This material shall conform to AASHTO M 249. Drop on glass beads shall conform to AASHTO M 247.

2.3 **PREFORMED PAVEMENT MARKING**

A. Preformed pavement markings shall consist of white or yellow films with clear and/or yellow-tinted microcrystalline ceramic beads incorporated to provide immediate and continuing retroreflection. These films shall be manufactured without the use of lead chromate pigments or other similar, lead-containing chemicals.

B. Preformed pavement markings shall be capable of being adhered to asphaltic cement concrete and Portland cement concrete by a pre-coated pressure sensitive adhesive.

C. The pavement markings shall be capable of application on new, dense and open-graded asphalt concrete wearing courses during the paving operation in accordance with manufacturer’s instructions. After application, the markings shall be immediately ready for traffic.

D. The markings shall be highly durable, retroreflective, pliant polymer materials designed for longitudinal and word/symbol markings subjected to high traffic volumes and severe wear conditions such as shear action from crossover or encroachment on typical longitudinal configurations such as edge lines and lane lines.

E. The retroreflective pliant polymer pavement markings shall consist of a mixture of high-quality polymeric materials, pigments and glass beads distributed throughout its base cross-sectional area, with a reflective layer of microcrystalline ceramic beads bonded to a durable polyurethane topcoat surface. The patterned surface shall have approximately 50% ±15% of the surface area raised and presenting a near vertical face to traffic from any direction. The channels between the raised areas shall be substantially free of exposed beads or particles.

F. The patterned material without adhesive shall have a minimum caliper of 0.065” at the thickest portion of the patterned cross section and a minimum caliper of 0.020” at the thinnest portion of the cross section.
PART 3 – EQUIPMENT

3.1 PAINT

A. Paint shall be applied by means of a machine of the spray type capable of satisfactorily applying the paint under pressure through a nozzle spraying directly upon the pavement. The machine shall be equipped with air blast device for cleaning the pavement ahead of the painting operation, a guide pointer to keep the machine on an accurate line, and a device to agitate the paint. It shall also have a device to maintain a uniform flow and application of the paint, an automatic device to provide a broken or skip line of the length required, and at least 2 spray guns capable of being operated either individually or together. When using waterborne paint, the equipment shall be capable of heating the material from ambient air temperature to 123 degrees F. The machine shall be equipped with a bead or sphere dispenser, which can be regulated to dispense the spheres automatically at the uniform rate required.

B. Each spray application machine must be equipped with an automatic counting mechanism capable of recording the number of linear feet of material applied to the roadway surface with an accuracy of 0.50%. Each spray application machine shall also be equipped with accurate meters, which register paint quantities for both white and yellow applied to the nearest gallon.

3.2 THERMOPLASTIC

A. The material shall be applied to the pavement by the screed extrusion method wherein one side of the shaping die is the pavement, and the other three sides are contained by, or are part of, suitable equipment for heating and controlling the flow of the material.

B. Each application machine must be equipped with an automatic counting mechanism capable of recording the number of linear feet of material applied to the roadway surface with an accuracy of 0.50%.

C. The equipment shall be constructed to provide continuous mixing and agitation of the material. Conveying parts of the equipment between the main material reservoir and the shaping die shall be so constructed as to prevent accumulation and clogging.

D. All parts of the equipment that come in contact with the material shall be so constructed as to be easily accessible for cleaning and maintenance.

E. The equipment shall be constructed so that all mixing and conveying parts up to and including the shaping die, maintain the material at the plastic temperature with heat transfer oil or electrical element controlled heat. Direct fire heat transfer will not be allowed.

F. The equipment shall be so constructed as to insure continuous uniformity in the dimensions of the stripe. The applicator shall provide a method of applying “skip” lines.
G. Glass spheres applied to the surface of the completed stripe shall be applied by an automatic bead dispenser attached to the striping machine in such a manner that the beads are dispensed almost instantaneously upon the installed line.

H. Special kettles shall be provided for melting and heating the thermoplastic material. The kettles must be equipped with automatic thermostatic control devices so that heating can be done by controlled heat transfer rather than by direct flame, so as to provide positive temperature control and prevent over heating of the material.

I. Applicators shall be mobile and maneuverable to the extent the straight line can be followed and normal curves can be made in a true arc.

3.3 PREFORMED PAVEMENT MARKING

A. The manufacturer shall provide automatic application equipment capable of applying an unlined, pre-coated, pressure sensitive adhesive pavement marking tape.

B. The automatic unit shall have the capability of advancing, applying and cutting the pavement marking tape at specific pre-programmed lengths, at speeds up to 6.5 mph when towed by an appropriate vehicle.

PART 4 – EXECUTION

4.1 PAINT

A. Temporary markings on final pavement surfaces shall be carefully located and placed so as to underlie or coincide with the permanent pavement markings.

B. No paint shall be applied over a chalk line, wire, or chord, but such guide marks shall offset the paint line to be placed.

C. Drop-on gall beads shall be uniformly applied to the painted surface at a uniform rate of not less than six pounds per gallon of paint applied.

D. Paint shall be applied so as to deposit a uniform wet film thickness of 0.015 ± inches. This is at the rate of 17 gallons per mile, for a solid stripe 4 inches wide.

E. The general appearance shall be that of clearly delineated lines with a minimum crooked and waving appearance, due consideration being given to the contours and roughness of the pavement. Segments of broken lines shall be without mist, drip or splatter. Lines that do not meet these requirements when placed shall be removed and/or corrected by the Contractor to the satisfaction of the Engineer and without extra compensation.

4.2 THERMOPLASTIC

A. The pavement temperature shall be a minimum of 50 degrees F and rising before application begins. Application shall be suspended at any time the pavement temperature falls below 50 degrees F.
B. All surfaces to be marked shall be thoroughly cleaned of all dust, dirt, grease, oil and all other foreign matter before application of the striping.

C. To insure optimum adhesion of the thermoplastic applied on all Portland cement concrete pavement, the Contractor shall apply a binder-sealer material as recommended by the thermoplastic manufacturer. A binder-sealer material shall also be applied to asphaltic concrete pavements, which have been open to traffic for ninety or more days.

D. Longitudinal lines shall be offset at least 2 inches for longitudinal joints of Portland cement concrete pavements.

E. A minimum average film thickness of 0.090 inches for lane and edge lines shall be maintained on all markings. The film thickness shall be uniform in appearance throughout its application. The glass sphere top coating must be applied by means of a pressure type spray gun designed specifically for this purpose, and which will embed the spheres into the line surface to at least one-half their diameter. The glass spheres shall be applied at the rate of 1 pound per 10 square feet of compound.

F. When thermoplastic is used on the final surface, the Contractor shall have the option of using reflectorized paint installed to permanent standards at the end of each day’s work and then installing the permanent marking after the paving operation is completed. Short unmarked sections shall not be allowed. The temporary markings for the final surface will not be measured and paid for directly, by the costs are to be included in the price bid for the permanent markings.

4.3 PREFORMED PAVEMENT MARKING

A. The markings shall be applied in accordance with the manufacturer’s installation instructions. Marking configurations shall be in accordance with the “Manual on Uniform Traffic Control Devices.”

Markings shall be applied before public traffic is allowed on the freshly paved surface. Preferably, the markings should be inlaid in the fresh surface during the final rolling of the mat, but in any case, they shall be applied before the close of the day.

END OF SECTION 02745 – PAVEMENT MARKINGS
PART 1  GENERAL

1.1  DESCRIPTION OF WORK

This work shall consist of constructing sports field fencing, tennis court fencing, and gates at locations shown on the plans.

1.2  SUBMITTALS

Fencing and all accessories shall be produced by a single manufacturer. Submit 5 copies of the manufacturer’s technical data, shop drawings, and installation instructions.

1.3  REFERENCES

ASTM A 53/A 53 M (2006) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

ASTM A 121 (1999; R2004) Metallic-Coated Carbon Steel Barbed Wire


ASTM A 153/A 153 M (2005) Zinc-Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A 392 (2003) Zinc-Coated Steel Chain-Link Fence Fabric

ASTM A 824 (2001) Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence


ASTM F 626 (1996a; R 2003) Fence Fittings

PART 2 - PRODUCTS

2.01 POSTS, RAILS, BRACES AND BARBED WIRE

A. All structural and roll formed shapes shall conform to the provisions of ASTM A123 for galvanized coating.
B. All tubular members shall comply with the provisions of ASTM F 1083 for weight and coating.
C. Metal framework shall meet strength and protective coating requirements of ASTM F 1043.
D. End, Corner, and Pull Post: For fence up to and including 12'-0" in height, 3-1/2" x 3-1/2" roll formed corner section shall have a minimum bending strength of 452 pounds (2.875" outside diameter, Schedule 40 pipe with a minimum bending strength of 381 pounds).
E. Line Posts (10'-0" Maximum Spacing): Fabric up to and including 12'-0" in Height: C-section, heavy roll formed, 2.25" x 1.70" with a minimum bending strength of 314 pounds (2.375" outside diameter, Schedule 40 pipe with a minimum bending strength of 201 pounds).
F. Gate Posts: Gate leaves up to and including 6'-0" Wide: 3-1/2" x 3-1/2" roll formed section (2.875" outside diameter, Schedule 40 pipe).
G. Top Rail: ASTM F 1083. The top rail shall be a 1.625" x 1.25" roll formed section with a minimum bending strength of 192 pounds (1.660" outside diameter, Schedule 40 pipe with a minimum bending strength of 202 pounds).

1. Furnish in the manufacturer’s standard lengths of approximately 21'-0", with couplings approximately 6" long for each joint. One coupling in each five shall have an expansion spring. Provide means for attaching top rails securely to each gate, corner, pull and end posts. The top rail shall form a continuous brace from end to each run of fence.

H. Tension Wire: Tension wire shall be Type I or Type II, Class 4 coating, in accordance with ASTM A 824.

H. Post Bracing Assembly: ASTM F 1083. To match top rail. Brace rail assembly shall be complete with a 3/8" diameter rod and adjustable take-up.

I. Barbed wire: ASTM A 121. Barbed wire shall consist of 3 strands of 12.5 gauge twisted galvanized steel wire with 14 gauge galvanized steel point barbs, 5" apart.
2.02 CHAIN LINK FABRIC

A. ASTM A 392, Class 2, zinc-coated steel wire with minimum coating weight of 2.0 ounces of zinc per square foot of coated surface. Fabric shall be fabricated of 9 gauge wire woven in 2 inch mesh. Fabric height shall be 6 feet, with the exception of 12-foot fencing surrounding the tennis courts.

B. Selvage Edges: Fabric 72” and more shall be knuckled at the bottom selvage and be twisted and barbed at the top.

2.03 ACCESSORIES

A. ASTM F 626. Ferrous accessories shall be zinc or aluminum coated.

B. Post Tops: Pressed steel or malleable iron (designed as a weathertight closure cap for tubular posts). Where top rail is used, provide tops to permit the passage of the top rail.

C. Stretcher Bars (for tubular end, corner, pull, or gate posts only): One piece lengths equal to the full height of the fabric, with a minimum cross section of 3/16” x ¾”. Provide one stretcher bar for each gate and end post and two for each corner and pull post.

D. Stretcher Bar Bands: Heavy pressed steel spaced not over 15” on center to secure stretcher bars to tubular end, corner pull, and gate post.

E. Wire Ties: For tying fabric to line posts, use 11 gauge steel wire clips for C-section posts and a minimum 9 gauge aluminum wire ties for tubular posts, spaced 14” on center. For tying fabric to rails and braces, use 9 gauge aluminum wire ties spaced 24” on center. For tying fabric to tension wire, use 11 gauge hog rings spaced 24” on center.

F. Miscellaneous hardware coatings shall conform to ASTM A 153/A 153M unless modified.

2.04 GATES

A. Gates shall meet the requirements of ASTM F 900.

B. Fabricate gate perimeter frames of 1.90” outside diameter tubular members galvanized in accordance with ASTM A123. Provide additional horizontal and vertical members to ensure proper gate operation and to allow for attachment of fabric, hardware, and accessories.

C. Assemble gate frames by welding or fittings and rivets for rigid connections. Use same fabric as for fence,(Mechanical Yard gate fabric shall be vinyl coated) unless otherwise indicated. Install fabric with stretcher bars at vertical edges, and tie at top and bottom edges. Attach stretcher bars to gate frame at not more than 15” o center. Attach hardware with rivets or by other means that will provide security against removal or breakage.

D. Provide diagonal cross bracing that consists of 3/8” diameter adjustable length truss rods on gates where necessary to provide frame rigidity without sag or twist.
E. Gate Hardware: Provide the following hardware and accessories, with a heavy galvanized finish, for each gate:

1. Hinges: Pressed steel or malleable iron to suit gate size, nonlift-off type, offset to permit 180 degrees gate opening. Provide one pair of hinges for each leaf.

2. Latch: Forked type or plunger bar type to permit operation from either side of the gate. Provide padlock eye as an integral part of the latch.

3. Keeper: Provide a keeper for all vehicle gates that automatically engages the gate leaf and holds it in the open position until manually released.

4. Double Gates: Provide gate stops for all double gates consisting of mushroom type or flush plate with anchors. Set in concrete to engage the center drop rod or plunger bar. Provide locking device and padlock eyes as an integral part of the latch, with one padlock for locking both gate leaves.

PART 3 EXECUTION

3.01 INSTALLATION

A. The packing for all products should be Level C.

B. Set all posts in a 3,000 psi concrete footing. Trowel smooth the top of each footing at a 20 angle from the post to the surrounding ground so as to shed water away from the post. The post shall extend to the full depth of the footing. The diameter and depth of footings for various fence heights shall be as specified on the drawings.

C. Install all fencing to the limits shown on the drawings. Install end or corner posts at any break in the alignment greater than 20 degrees. Install intermediate posts between end or corner posts, spaced equally at a maximum of 10’ center to center. Install end, corner, or gate posts on both sides of a gate. Only one end or corner post shall be installed at the junction of different heights of fence and shall be consistent with the largest post required at the junction. Install gates to allow a clear and level swing in either direction to their maximum limit. Set all posts with a vertical tolerance of less than 1” in 10’ as measured with a plumb bob. Install gate stops.

D. All corner, terminal and gate posts for fence 6’ and higher shall have a midrail and 3/8 round adjustable truss rod to the next post.

E. All gates shall have a full wraparound hinge system with a positive latch with provision for a padlock.

F. All fences shall have a bottom tension wire attached to the fabric and posts.

END OF SECTION 32 31 13 – CHAIN-LINK FENCING
PART 1 – GENERAL

1.01 WORK INCLUDED

A. Establish lawn areas covered by new construction as defined on construction documents.

B. Provide water for lawn operations.

1.02 QUALITY ASSURANCE

A. Guideline specification to turf grass sodding; American Sod Producers Association (ASPA); 1988.

B. Randomly select five soil samples from areas to be established as lawns and allow an adjustment of contract if the fertilizer or limestone requirements need to be adjusted.

C. Have selected soil samples analyzed by an approved laboratory, for nitrogen, phosphorus, and potash content, and pH level. (Note: Owner's Representative will determine acceptability of testing laboratory.)

D. When laboratory analysis is received, deliver copy to the Owner's Representative. Owner's Representative will then specify the exact fertilizer, soil amendments, and recommended quantities for application.

1.03 SUBMITTALS

A. Submit items to Owner's Representative in accordance with this section.

B. Submit required information about fertilizer, seeds and sod, and obtain approval of Owner's Representative before delivering items to project site.

1. Fertilizer: Manufacturer's statement of analysis, indicating percentages of nitrogen, phosphorus, and potash, proportion of organic and inorganic matter contained, and availability of plant food.

2. Seeds: Certification stating that seeds meet requirements.

3. Sod: Certification stating that sod is free from disease, nematodes, and undesirable insects; is not subject to quarantine restrictions; and is equal to or exceeds quality specified.

1.04 DELIVERY AND STORAGE

A. Deliver fertilizer and seed to the project site in manufacturer's original, unopened containers bearing guaranteed analyses of products.
B. Deliver sod tagged with the correct botanical and common names of the species. Protect from breaking and drying out. Do not deliver more sod than can be laid within 24 hours following delivery.

c. Contractor shall water sod up to substantial completion but not less than 2 weeks. Contractor to mow up to substantial completion but not less than 2 mowings.

D. Store fertilizer and seeds off ground in a dry, cool area.

E. Store sod in an area to prevent exposure to wind or direct sunlight and from drying out and heating up.

PART 2 – PRODUCTS

2.01 FERTILIZER AND LIMESTONE

A. Fertilizer and limestone specified here is a guide to determining cost estimate. Exact contents and quantities required will be determined after soil analyses are made, but no price adjustment will be made by Owner because of minor variations.

1. Fertilizer: a complete fertilizer with organic base containing 10 percent nitrogen, 10 percent phosphoric acid, and 10 percent potash. Provide material in free flowing form.

2. Limestone: finely ground limestone containing at least 45 percent calcium oxide, pulverized so that residue on #30 and #200 sieves is not more than 5 percent and 15 percent, respectively.

2.02 SEED

A. Grass Seed: The seed shall meet purity and germination rates as required by Department of Agriculture, and no below-standard seed will be accepted.

1. Grass seed furnished under these specifications shall be packed in new bags or in sound bags that have not been mended.

B. A certificate of purity for all seed will be submitted to the Owner’s Representative.

C. Samples of materials may be requested for verification of purity at the discretion of the Owner’s Representative.
2.03 SEED MATERIALS

A. Inspect and test seed for germination and purity prior to mixing.

B. Uniformly mix by Group:

<table>
<thead>
<tr>
<th>Seed Name</th>
<th>Quantity % by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GROUP &quot;A&quot;</strong></td>
<td></td>
</tr>
<tr>
<td>Lespedeza (common or Korean)</td>
<td>20%</td>
</tr>
<tr>
<td>Sericea Lespedeza</td>
<td>15%</td>
</tr>
<tr>
<td>Kentucky 3l Fescue</td>
<td>40%</td>
</tr>
<tr>
<td>English Rye</td>
<td>25%</td>
</tr>
<tr>
<td><strong>GROUP &quot;B&quot;</strong></td>
<td></td>
</tr>
<tr>
<td>Kentucky 3l Fescue</td>
<td>55%</td>
</tr>
<tr>
<td>Redtop</td>
<td>15%</td>
</tr>
<tr>
<td>English Rye</td>
<td>30%</td>
</tr>
<tr>
<td><strong>GROUP &quot;C&quot;</strong></td>
<td></td>
</tr>
<tr>
<td>Sericea Lespedeza</td>
<td>50%</td>
</tr>
<tr>
<td>Kentucky 3l Fescue</td>
<td>30%</td>
</tr>
<tr>
<td>English Rye</td>
<td>20%</td>
</tr>
</tbody>
</table>

C. Use Group "A" seed from February 1 to August 1.

D. Use Group "B" seed from August 1 to December 1, with the exception that either Group "A" or "B" may be used during the month of August.

E. Use Group "C" seed from February 1 to December 1 only when specified on the Plans or otherwise approved.

F. All seed shall meet the requirements of the Tennessee Department of Agriculture.

G. Furnish the Designer a certified laboratory report showing the analysis of the seed to be furnished. The report shall bear the signature of a senior seed technologist.

H. Inoculant for Legumes:

1. Nitrogen fixing bacteria cultures adapted to the particular seed to be treated.

2. Furnish in containers of a size sufficient to treat the specified quantity of seed to be planted.
2.02 MULCH MATERIALS

A. Hay composed of approved stalks from grasses, sedges, or legumes; or straw composed of stalks from rye, oats, wheat, or other approved grains.

B. Air dried and reasonably free from noxious weeds, weed seeds, and other detrimental plant growth.

C. Suitable for spreading with mulch blower machinery.

d. No plastic twine shall be used with straw.

2.03 JUTE MESH

A. Open plain weave of single jute yarn and non-toxic to vegetation.

B. Tag jute rolls for identification with 58 warp ends per yard, 41 weft ends per yard and weighing approximately 0.9 pounds per square yard with an acceptable tolerance of 5 percent.

2.04 STAPLES

A. New and unused, machine made of No. 11 gauge steel wire formed into a "U" shape.

2.05 SOD MATERIALS

A. Live dense, well-rooted growth of permanent grasses, free from Johnson grass, nutgrass, and other undesirable grasses or weeds and well-suited for the proposed application to particular soils.

B. Sod placed around the building shall be Kentucky 31 Turf-type Fescue or Bermuda sod as required by the owner and seasonal limitations.

B. Cleanly cut in strips having a reasonably uniform thickness of not less than 2 ½ inches, a uniform width of approximately 8 inches, and a minimum length of 12 inches.

2.06 COMMERCIAL FERTILIZERS

A. Unless otherwise specified, inorganic 10-20-10 nitrogen, phosphoric acid, and potash for seeding and 15-15-15 or 10-10-10 for sodding.

B. Furnish in standard containers with the brand name, weight and guaranteed analysis of the contents clearly marked.

C. Comply with Federal, State, and local laws.
D. Ammonium Nitrate shall be a standard commercial product, having a minimum of 33.5 percent nitrogen.

E. Agricultural limestone shall contain a minimum of 85% of calcium carbonate and magnesium carbonate combined, and be of particular size that 85% will pass a No. 10 mesh sieve.

2.07 WATER

A. Free from harmful organisms or other objectionable materials. The contractor shall provide the required water for stabilized areas until final acceptance of the project or 3 weeks, whichever is longer.

2.08 TOPSOIL

A. Natural, friable fertile, fine sandy loam processing characteristics of representative top soils in the vicinity which produce heavy growths of vegetation.

B. Free from subsoil, noxious weeds, stones larger than one inch in diameter, lime, cement, ashes, slag, or other deleterious matter.

C. Well drained in its original position and free from toxic quantities of acid or alkaline elements.

PART 3 - EXECUTION

All unpaved areas disturbed by the construction of this project, or any other areas as specified, shall have a stand of grass developed by one of the following methods: Seeding will generally be acceptable. Sodding shall be used around the school buildings as directed in the Contract.

3.01 SEEDING

A. Scarify, disc, harrow, rake or otherwise work each area to be seeded until it has been loosened and pulverized to a depth as directed by the Designer.

B. Uniformly incorporate fertilizer into the soil for a depth of approximately 1/2" at the rate of:

1. Not less than 20 lbs. per 1000 square feet for grade 10-10-10 or equivalent.

2. Not less than 100 lbs. per 1000 square feet for agricultural limestone.

C. Fertilizer need not be incorporated in the soil as specified above when mixed with seed in water and applied with power sprayer equipment.
D. Sow seed of the specified group as soon as preparation of the seedbed has been completed.

E. Sow uniformly by means of a rotary seeder, hydraulic equipment, or other satisfactory means at the rate of eight (8) pounds per 1000 square feet, unless otherwise specified.

F. Inoculate Group "C" seed and seeds of legumes, when sown alone, before sowing in accordance with the recommendations of the manufacturer of the Inoculant.

G. Do not perform seeding during windy weather, or when the ground surface is frozen, wet or otherwise non-tillable. No seeding shall be performed during December through February unless otherwise permitted.

H. When specified, provide seeding with mulch:
   1. Spread hay or straw mulch evenly over the seeded area at an approximate rate of 75 pounds per 1000 square feet immediately following the seeding operations. This rate may be varied by the Designer, depending on the texture and condition of the mulch material and the characteristics of the area seeded.
   2. Hold hay or straw mulch in place by the use of a mulch binder applied at the approximate rate of 4 gallons per 1000 square feet as required.
   3. Cover bridges, guardrails, signs and appurtenances, if the mulch binder is applied in such a way that it would come in contact with or discolor the structures.
   4. When wood fiber mulch is used, uniformly apply at the rate of 28 to 35 pounds per 1000 square feet with hydraulic mulching equipment.

3.02 SODDING

A. Place sod where directed on the plans but at a minimum, 50 surrounding the perimeter of the building.

B. Loosen the surface of the ground to be sodded to a depth of not less than one inch with a rake or other device.

C. If necessary, sprinkle areas to receive sod with water until saturated for a minimum depth of one inch and keep moist until the sod is placed.
D. Immediately before placing the sod, fertilize the prepared surface uniformly at the rate of:
   1. 12 lbs. per 1000 square feet for grade 10-10-10 or equivalent.
   2. 100 lbs. per 1000 square feet for agricultural limestone.

E. Place sod as soon as practical after removal from the point of origin, and keep in a moist condition during the interim.

F. Carefully place, by hand, on the prepared ground surface with the edges in closed contact and, as far as possible, in a position to break joints.

G. Each strip of sod laid shall be fitted and pounded into place using 10-inch wood tramps, or other satisfactory implements.

H. Immediately after placing, thoroughly wet and roll with an approved roller or hand-tamp as approved by the Engineer.

I. On slopes of two to one or steeper, pinning or pegging may be required to hold the sod in place.

3.02 TOPSOIL

A. The contractor shall save and stockpile the topsoil removed from the excavation area or otherwise obtain topsoil to restore the area and reestablish an acceptable stand of grass.

B. Prepare landscape area to receive topsoil in close conformity to the lines and grades shown on the drawings.

C. Place topsoil at depths and locations shown on the drawings or as otherwise necessary to promote a good stand of grass.

3.03 MOWING

A. Contractor shall mow all seeded and sodded areas a minimum of two (2) times after lawn is established.

END OF SECTION 32 91 00 - LANDSCAPING
PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

This work shall consist of constructing manholes, catch basins, inlets and pipe end walls at the locations shown on the Plans, and in reasonably close conformity to the lines, grades, and design dimensions shown on the plans, or as directed by the Engineer.

The work shall include the furnishing and installation of such incidental appurtenances and connections to pipe and other structures as may be required to complete the construction as shown on the Plans or as directed by the Engineer.

1.2 RELATED SECTIONS

A. Section 33 40 00 - Storm Sewers
B. Section 32 16 13 - Cast-in-Place Concrete

1.3 SUBMITTALS

A. Product data for materials and items, including manhole frames, covers, steps, grates and castings.
B. Shop drawings detailing reinforcement, fabrication, structural steel, required openings, etc.

1.4 REFERENCES

A. American Society for Testing and Materials
   2. ASTM A-615-90: Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

PART 2 – PRODUCTS

A. Concrete Manholes and Catchbasins:
   1. Concrete Base: Precast or cast-in-place, at Contractor’s option. Use concrete, which will attain a 28-day compressive strength of not less than 3,000 psi.
   2. Precast Concrete Manholes and Catchbasins: ANSI/ASTM C 478, sized as indicated.
   3. Structural Steel: All rolled plates, shapes and bars for structural use shall conform to ASTM A 36.
   4. Steel Bar Reinforcement: All steel reinforcement shall be billet steel bars conforming to the requirements of ASTM A-615, Grade 60.
B. Metal Accessories:

1. Manhole Frames and Covers: Grey cast iron, ANSI/ASTM A 48, Class 30 B.
   a. All castings shall be cleaned of sand and scale by sand blasting or other effective methods so as to present a smooth, clean, and uniform surface.
   b. Furnish covers with cast-in legend (“STORM” or “SANITARY” to suit installation) on roadway face.

PART 3 – EXECUTION

3.1 STRUCTURE EXCAVATION

A. Before excavation is started the Contractor when required, will set stakes locating and outlining the structure.
B. All excavation shall be cut to the lines and elevations indicated on the Plans, or as directed by the Engineer.
C. Inclined surfaces of rock used as foundation shall be excavated either level or in steps. When necessary, the surface of rock foundation shall be roughened, or suitable anchors installed.
D. The Contractor will be held responsible for protecting his excavation and shall take every precaution to maintain the excavation intact.

3.2 FOUNDATION PREPARATION

A. When the foundation has been completed to foundation elevation as given, the Engineer shall be notified and the construction therein withheld pending his inspection and approval of the foundation.
B. Rock used as foundation shall be stripped and cleaned of all overlying materials. All loose, disintegrated, or light slabby portions of the rock shall be removed.
C. Unsatisfactory material in the foundation shall be removed and replaced with satisfactory material placed in layers not exceeding six inches in loose depth and compacted to 95% of maximum density up to the foundation elevation.

3.3 BACKFILLING

A. All areas that have been excavated, the volume of which is not occupied by the structure, shall be refilled with acceptable earth material to the normal ground surface.
B. Granular backfill for structures shall be AASHTO M 43 #57 or #67 and shall be placed in layers not exceeding six inches in loose depth and compacted to 95% of maximum density.
C. Backfill shall not be placed against a structure of a section or unit thereof, until representative specimens of the concrete in the structure, section or unit, attain a compressive strength of 3,000 psi.

3.4 CONCRETE CONSTRUCTION

A. All concrete construction shall be accomplished in accordance with the requirements of Section 03305 – Cast-In-Place Concrete.

3.5 INVERTS

A. Inverts shall be of concrete, which will attain a 28-day compressive strength of not less than 3,000 psi and shall conform to the shaped indicated on the Plans.

B. Inverts shall be so constructed as to cause the least possible resistance to flow. The shape of the inverts shall conform uniformly to inlet and outlet pipes.

3.6 PRECAST CONCRETE MANHOLES

A. Place precast concrete sections as shown on drawings. Where manholes occur in pavements, set tops of frames and covers flush with finish surface. Elsewhere, set tops 3” above finish surface, unless otherwise indicated.

B. Use epoxy bonding compound where manhole steps are mortared into manhole walls.

C. Apply bituminous mastic coating at joints of sections.

3.7 CATCH BASINS

A. Construct catch basins to the sizes and shapes indicated.

B. Use concrete which will attain a 28-day compressive strength of not less than 3,000 psi.

C. Set cast-iron frames and gratings to elevations indicated.

3.8 PIPE END WALLS

A. Construct pipe end walls to the sizes and shapes indicated.

B. Use concrete, which will attain a 28-day compressive strength of not less than 3,000 psi.

3.9 TAP CONNECTIONS

A. Make connections to existing conduits and underground structures, so that finished work will conform as nearly as practicable to requirements specified for new work.
3.10 CASTINGS AND FITTINGS

A. Castings and fittings shall be handled in a manner that will prevent damage. All damaged castings and fittings shall be rejected.

B. All castings and fittings shall be placed in the positions indicated on the Plans or as directed by the Engineer, and shall be set true to line and grade.

C. When casting is to be placed upon constructed masonry, the bearing surface of masonry shall be brought true to line and grade and present an even bearing surface in order that the entire face of back of the casting will come in contact with the masonry.

D. Castings shall be set in mortar beds or anchored to the masonry as indicated on the Plans or as directed by the Engineer.

E. Unless otherwise specified, gray iron casting shall be cleaned and treated with two coats of bituminous paint.

END OF SECTION 33 05 00 – CONCRETE STRUCTURES
PART I - GENERAL

I.1 WORK INCLUDED

A. Installation, testing and disinfection of water service and fire lines and appurtenances.

I.2 RELATED WORK

Section 310000 – EARTHWORK

PART 2 - PRODUCTS

2.1 POLYVINYL CHLORIDE PIPE (PVC) AND FITTINGS

A. Provide PVC pipe meeting ASTM D-224 or AWWA C-900.

B. ASTM D-224l Pipe:
   (1) Manufactured from virgin, National Sanitation Foundation (NSF) approved Type I, Grade I impact improved resin suitable for use in transporting potable water.
   (2) Pipe and fittings pressure rated for 200 psi.
   (3) Use only where the maximum pressure shall not exceed 2/3 of the pressure rating or 135 psi.
   (4) Maximum Standard Dimension Ratio (SDR) of 2l.
   (5) Joints sealed with a rubber ring and non-toxic lubricant as provided by the manufacturer meeting or exceeding the requirements of ASTM D-3139 and ASTM F-477.
   (6) Clearly mark with the manufacturer’s name, nominal diameter, SDR, ASTM D-224l, pressure rating, and NSF approval seal.

C. AWWA C-900 Pipe:
   (1) PVC 1120 pipe manufactured from virgin, National Sanitation Foundation (NSF) approved compounds meeting the requirements of ASTM D-1784.
   (2) Pressure rated based on Standard Dimension Ratios (SDR) and pressure classes (pressure classes are working pressure ratings):
Standard Dimension Ratio (DR): Pressure Class (psi):

<table>
<thead>
<tr>
<th>DR</th>
<th>Pressure Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>100 (for force mains only)</td>
</tr>
<tr>
<td>18</td>
<td>150</td>
</tr>
<tr>
<td>14</td>
<td>200</td>
</tr>
</tbody>
</table>

(3) Outside diameter equivalent to the same outside diameter of cast iron pipe.

(4) The minimum wall thickness of the bell, at any point, shall conform to the DR requirements of the pipe.

(5) Furnish in standard laying lengths of twenty (20) feet.

(6) Clearly mark with the manufacturer's name, nominal diameter, DR, PVC 1120, pressure class, AWWA C-900, and NSF approval seal.

D. ASTM F-1483 (Ultra-Blue or equal):

Ultra-Blue or equal molecular oriented polyvinyl chloride pipe manufactured to ASTM D-1784, ASTM D-2241 and ASTM D-3139 may be used on specific project approval basis by the City Engineer's office.

E. PVC Fittings:

(NOT ALLOWED FOR WATER MAINS)

2.2 DUCTILE IRON PIPE AND FITTINGS

A. Pipe:

(1) Manufactured in accordance with ANSI A-21.50 (AWWA C-151) and NASI A-21.10 (AWWA C-110).

(2) A cement lining meeting the requirements of ANSI 21.4 (AWWA C-104).

(3) A minimum of 1 mil thick bituminous coating on the outside surface.

(4) Clearly mark with manufacturer's name, D.I. or Ductile, weight, class or nominal thickness, and casting period.

(5) Unless otherwise specified or shown on the plans, ductile iron pipe shall be pressure class 350.
B. Fittings:

All fittings and specials for pipe 4 inches in diameter and larger shall be cast or ductile iron.

(1) Fittings 3" - 24": Pressure rated at 350 psi.
(2) Fittings 30" - 36": Pressure rated at 250 psi.
(3) Joints meeting the requirements of ANSI 21.53/AWWA C-153 for compact iron pipe.
(4) Gaskets meeting the requirements of AWWA C111.

2.3 SERVICE PIPE

A. Polyethylene and PVC Pipe:

Metallic detector tape shall be installed above the service line for all nonmetallic service lines between the main and the meter.

Polyethylene or PVC is acceptable for use between the meter and the building in accordance with the Standard Plumbing Code. Polyethylene or PVC plastic pipe is not approved for service lines from the main to the meter unless said service pipe is 4 inches or greater in which case class 200 or schedule 40 PVC may be used.

B. Copper Pipe:

(1) Seamless copper tubing meeting the requirements of ASTM B-88, Type K for 3/4" and 1". Copper tubing larger than 1" may be hard or soft. All underground copper to copper connections are to be by compression coupling, no solder sweat joints.
(2) Contain not less than 99.90% copper and not more than 0.04% phosphorous.
(3) Suitable for use with a working water pressure of 160 psi.
(4) 3/4 inch nominal diameter unless otherwise specified or shown on the Plans.
(5) Service pipe shall be used to connect the corporation stop with the meter yoke. Use the minimum length required to make a straight line connection including a gooseneck. The minimum length of service shall be 5 feet in order to facilitate the location of the services with metallic pipe locators.

2.4 WATER MAIN ASSEMBLIES

A. Water Meters (all water meters are issued by the City of Clarksville):

(1) AWWA C-700.
(2) 5/8" x 3/4" unless otherwise specified or shown on the plans.
(3) Frost proof with a cast bronze casing and a hinged cover.
(4) Direct reading register, in gallons.
(5) Disc or piston operated with magnetic drive.
(6) A suitable non-corrosive strainer located over the inlet to the measuring chamber.
(7) The name of the manufacturer cast in the lid of the register box and the meter serial number imprinted thereon.

B. Water Main Connections:

(1) Tap water mains in the upper half of the pipe at a 45 degree angle or provide brass tapped couplings with AWWA threads.
(2) Do not exceed the pipe manufacturer’s recommended maximum tap size.
(3) Use service clamps on all taps for PVC pipe. Water service tapping saddles for services 2" or less are to be of total brass or bronze construction with no ferrous materials. Saddles are to have double straps or extra wide single straps.
(4) Service taps on line under construction that have been tested and inspected by the City may be made by a qualified contractor. Taps on existing City mains must be made by authorized City personnel unless specifically authorized by the City Engineer’s office.

C. Corporation Stops/Service Valves:

Corporation stops are required for all ¾” and one-inch services. Services of 2” diameter or greater may use a 2” ball valve with a square operating nut. All service valves of 2” diameter or greater shall have a standard valve box installed and brought to grade. Corporation stops shall meet the following criteria:

(1) AWWA C-800.
(2) Cast of certified waterworks red brass, composed of 85% copper and 5% each of tin, lead, and zinc.
(3) Water-tight and individually tested for leaks.
(4) Waterway diameter approximately equal to the nominal size of the stop.
(5) Coat or cap all threads for protection prior to installation.

D. Meter Yokes (all meter yokes are issued by the City of Clarksville):

(1) Copper tubing with an integral brace and meter stop.
(2) Minimum rise of 14”.
(3) Provide with outlets designed for the use of polyethylene or copper service pipe.
E. Curb Valves:

All water services less than 2" diameter must terminate with a curb ball valve immediately prior to the meter yoke location. Approved models are Mueller B25140R3, Ford B-41233 and Ford 13842333. Curb ball valves that are buried prior to the installation of a yoke shall have a bolt or pin placed in the stop wing to prevent the ball valve from being accidentally opened during back fill.

F. Meter Boxes (all meter boxes are issued by the City of Clarksville):

(1) All meter boxes are to be located in non-traffic areas and as close to the R.O.W. as possible.
(2) The depth of the meter inlet for 5/8" – 1" meters shall be 18" to 24".
(3) The depth of the meter inlet for 1 ½" – 6" meters shall be 24" to 36".
(4) Meter box to be of sufficient size to facilitate easy installation and removal of the water meter.
(5) Where service assemblies include a pressure reducing valve, sufficiently sized for installation of the pressure reducing valve in the meter box.

G. Pressure Reducing Valves for Service Assemblies:

Pressure reducing valves are the responsibility of the customer and may be installed at any point downstream of the meter in accordance with the Standard Plumbing Code. Pressure reducing valves are required where the static pressure is greater than 80 psi.

H. Service Materials:

No galvanized pipe, galvanized nipples, black iron, glued plastic or sweated fittings are to be used between the main and the meter yoke. Threaded brass, slip joints, mechanical joints, and bronze/brass compression fittings are allowed.

2.5 VALVES AND VALVE BOXES

A. Gate Valves:

(1) AWWA C-509 or C-515
(2) Iron body, resilient seat, non-rising stem type.
(3) Stuffing boxes: 0-ring seal type with two (2) rings in the stem located above the thrust collar.
(4) 2” square wrench nut for operation of the valve.
(5) Minimum design working water pressure of 200 psi for valves with diameters 2”-12” and 150 psi for valves with diameters of 14”-54”, unless otherwise specified or shown on the plans.

(6) Joints: ANSI A-2ll (AWWA C-lll).

(7) Bonnet or body markings: Manufacturer’s name, year of casting, size, pressure rating, and OPEN with direction.

B. Butterfly Valves:

(1) AWWA C-504.

(2) Cast iron body, rubber seated tight-closing type.

(3) Cast markings: valve size, manufacturer’s name, class, direction of opening, and the year of casting.

(4) Class 150, suitable for working water pressure of 150 psi unless otherwise specified or shown on the plans.

(5) All main line valves and hydrants in the old Clarksville, St. Bethlehem and Sango water systems are to open by turning to the right. Valve operating nuts and fire hydrants which open to the right shall be painted yellow. All main line valves and hydrants in the old New Providence, Edgoten, Kirkwood and North Montgomery areas are to open by turning to the left. Valve operating nuts and hydrants which open to the left shall be painted red. For other details see the attached map on water valve opening corrections or contact the City Engineer’s office for clarification.

C. Valve Boxes:

(1) Cast iron, 2 or 3 piece, screw type with shaft diameter of not less than 5” (John Bouchard 562-S or equal).

(2) Heavy roadway type equipped with a cover containing the word "WATER" in raised letters on the top.

(3) Base of such size as to permit its installation without allowing it to come in contact with either the valve or the pipe.

(4) In paved areas, the top of the box casting shall be made level with the adjacent pavement. In unpaved areas, the box shall be level with the adjacent ground and encircled with a concrete collar 4” thick and 2’ in diameter.

D. Tapping valves and sleeves:

(1) Tapping valves shall meet all the requirements specified for (A. Gate Valves) above and shall be Mueller T2360-16, M&H 4751-01 or equal. US brand tapping valves are not approved.
(2) Tapping sleeves shall be two piece fabricated stainless steel with adjusting/tightening bolts on each side. The fabricated sleeve must contain all stainless materials and be rated for the anticipated working pressure. Care must be used to assure that all bolts are equally tightened. The tapping sleeve must be pressure tested before the tap is made. The tapping valve is to be solidly supported with brick or block and carefully bedded to prevent shifting due to settling back fill.

2.6 AIR RELEASE ASSEMBLIES FOR WATER MAINS

A. Furnish in 1" nominal diameter for 8" mains and smaller, and in 2" nominal diameter for 10" mains and larger, unless otherwise specified or shown on the plans.

B. Air release assemblies shall consist of:

(1) Double strap, bronze service clamp with neoprene gasket (for PVC lines).
(2) Brass pipe of the nominal diameter required by the main size. No galvanized pipe is allowed.
(3) Red brass corporation stop.
(4) Brass elbow. No galvanized materials are allowed.
(5) Gate valve.
(6) Air release valve.

C. Combination air release valves consisting of:

(1) An air vacuum valve coupled with an air release valve.
(2) Cast iron body, stainless steel float, bronze linkage, bronze trim, suitable for use in mains having a working pressure of 200 psi.

D. Install in a pre-cast concrete manhole, 48" in diameter and 48" deep, nominal diameter cast iron frame and cover.

E. Place crushed stone from the top of the main to 12" below the bottom of the main.

2.7 FIRE HYDRANTS AND BLOW-OFF HYDRANTS

A. Fire Hydrants:

(1) AWWA C-502. Mueller or M&H are the standard for Clarksville.
(2) Cast iron bodies, fully bronze mounted, designed for operation at a working water pressure of 150 psi.
(3) Furnish with two 2-1/2" thread brass hose nozzles and one threaded brass pumper nozzle.
(4) Compression type main valve 5-1/4" diameter faced with a suitable yielding material such as rubber, leather, or balata.
(5) So designed that, when it is installed, no excavation is required to remove the main valve or the movable parts of the drain valve.

(6) Inside diameter of barrel: at least 120 percent of the hydrant valve size.

(7) Inlet connection: minimum of 6" mechanical joint on all lines, unless otherwise specified or shown on the Plans.

(8) Equipped with safety flange located not more than 10" above ground and a two piece shaft break-away assembly.

(9) All main line valves and hydrants are to open in the same direction as the existing main line valves. Contact the City Engineer's office for clarification.

(10) Shop paint and mark in accordance with AWWA C-502; open right hydrants – yellow, open left hydrants - red.

(11) Cast markings: manufacturer's name, size of the main valve, year of manufacture, and direction of opening

(12) Field touch-up, if the surface has been marred, with paint supplied by the manufacturer of the same color and type as that used during shop painting.

B. Blow-Off Hydrants:

(1) Post type having cast iron bodies, fully bronze mounted and designed for operation at a working water pressure of 150 psi.

(2) Furnish with either two 1-1/2" or one 2-1/2" threaded brass hose nozzle.

(3) Compression type main valve 2-1/8" minimum diameter faced with a suitable yielding material such as rubber, leather or balata.

(4) So designed that, when it is installed, no excavation is required to remove the main valve or the movable part of the drain valve.

(5) Inside diameter of barrel: at least 3".

(6) Inlet connection: 2" mechanical joint, unless otherwise specified or shown on the plans.

(7) Equipped with a safety flange located not more than 2" above the ground.

(8) Open on counter-clockwise operation, unless otherwise specified.

(9) Cast markings: manufacturer's name, size of the main valve, year of manufacture, and direction of opening

(10) If the surface has been marred, touch up with paint supplied by the manufacturer of the same color and type as that used during shop painting.
C. Blow-off Valves:

1) Where approved by the City Engineer’s office, a blow-off valve assembly may be used in lieu of a hydrant. The valve shall be located at the end of the dead-end line and a pipe shall be extended to the nearest ditch to accept the blow-off water. Rip-rap or concrete protection shall be provided as necessary to prevent erosion from the discharge. The blow-off valve shall be enclosed in a standard valve box. The valve and blow-off line shall be one inch for two-inch diameter supply mains. The blow-off shall be two inch for larger mains through six inch. For larger mains, the blow-off site shall be determined and shown on the Plans.

PART 3 - EXECUTION

3.1 PREPARATION

A. Prior to laying pipe, prepare suitable bedding according to Section 02200.

B. Unless otherwise specified, provide all water lines with a minimum of 4 feet of cover in roadways and 3 feet of cover in open areas, unless ductile iron pipe or concrete encasement is used. Pipe protection may also be required in other areas subject to erosion and or very heavy traffic.

C. Before placing pipe in the trench inspect for cracks or other defects. Remove defective pipe from the construction site.

D. Swab the interior of the pipe to remove all undesirable material.

E. Prepare the bell end and remove undesirable material from the gasket and gasket recess.

3.2 INSTALLING WATERLINES

A. Lay all pipe on a uniform grade and with deflections not exceeding the pipe manufacturer’s recommendations.

B. After applying gasket lubricant, take extreme care to keep the spigot end from contacting the ground.

C. Hone the pipe with suitable tools or equipment to provide a smooth beveled edge on plain end sections.

D. Closely follow the manufacturer’s instruction in laying and joining pipe.
E. Cut pipe for inserting valves, fittings, etc., in a neat and workmanlike manner without damaging the pipe so as to leave a smooth end at right angles to the axis of the pipe.

F. Locate waterlines in relation to other piped utilities in accordance with Section 02605.

3.2.1 IDENTIFYING TAPE AND WIRE

The location of all nonmetallic water mains installed under these specifications shall be marked by the use of a continuous blue tape, minimum three inches in width, made of minimum 5 mil thick polyethylene plastic with a 0.5 mil thick aluminum metallic core or backing. The tape shall be buried in the trench, above the pipe, no more than two feet below the surface. The tape shall be marked indelibly with the words “Water Main Below” or similar wording to warn unwary excavators.

An insulated minimum 14 gauge tracer wire shall also be installed in the ditch immediately along the water line, either attached to or periodically wrapped around the line at or near the bottom of the ditch. The wire shall be branched off at intervals of 500’± to connect to hydrants, valve boxes, or services to allow convenient surfaces access to the wire for pipe locator connection.

3.3 INSTALLING APPURTENANCES

A. Securely plug open ends of pipe at the close of each work day and during temporary discontinuance of pipe laying.

B. Set all valves, fittings, hydrants, and other specials in a neat workmanlike manner. Tapping valves are to be supported with blocking and surrounding bedding carefully compacted to prevent settlement.

C. Use thrust blocks, as shown on the Plans, pipe anchors, or other approved means to prevent displacement or other fittings. Do not allow concrete to cover nuts and bolts on fittings. Gate valves on fire hydrant leads are to be restrained or blocked independently of the hydrant blocking so that the hydrant may be excavated and removed with the valve closed. Mechanical restraint is to be by the use of mega lugs or other similar devices. Underground use of galvanized all thread rod is not approved. Fittings for taps made on the reverse side of the main must be restrained joints.

D. Erect hydrants to stand plumb with the pumper nozzle facing the road.

E. Effect drainage of hydrants by using 6 cubic feet of gravel around base of hydrant. Do not allow concrete thrust block to obstruct drain holes.
F. Close dead ends with cast iron plugs or caps and equip with blow-off assemblies, where shown on the drawings.

3.3.I CONNECTING NEW SYSTEM TO EXISTING SYSTEM.

Initial filling of the new line shall be made at only one point and shall be via a metered backflow assembly which is provided by the City, installed by the contractor, and then removed by the contractor and returned to the City after acceptance of the line.

A. All connections of new main extensions to existing systems shall be valved to prevent existing customers from being included in the new system area during testing and disinfection procedures.

B. Connections of new mains to existing mains shall normally be made by the use of a tapping valve in order to avoid disrupting service to existing customers.

C. Any wet connections involving the shutdown of existing system valves shall be specifically approved by and coordinated with the City Engineer's Office. Such coordination shall include the responsibility of the contractor in notifying affected customers and scheduling shutdowns to minimize customer inconvenience. An authorized shutdown shall not relieve the contractor from liabilities resulting from shutdowns such as damaged water heaters, discolored water, etc.

D. Manipulation of valves for filling or flushing lines shall be minimized to avoid accumulations of air and discolored water in the affected area.

E. When new systems are fully activated; following disinfection, flushing and testing; the contractor shall inspect each valve that has been installed or manipulated to insure that all valves are in a fully open position.

F. The contractor will be charged for the consumption volume of water by flushing, filling, leaks, etc. that exceeds twice the volume of the installed pipe.

G. Pipe Restraint

It is the intention of these specifications that all mechanical joint fittings and valves be restrained at each opening with Mega Lugs or equal mechanical restraints. These restrained fittings do not eliminate or replace the requirement for sufficient concrete thrust blocking and/or restrained pipe joints.

3.4 STREET CROSSINGS

Installation of utilities across City streets shall be performed as directed by the City of Clarksville Street Department.
3.5 WATER LINE PRESSURE TESTS

A. After the pipe has been laid, subject all newly laid pipe or any valved section thereof to a hydrostatic pressure of at least 200 psi at the lowest point of the line segment being tested.

B. Test pressures shall:

   (1) Not be less than 1.5 times the maximum working pressure at the lowest point along the test section.
   (2) Not exceed the pipe or thrust restraint design pressures.
   (3) Be of at least 2-hour duration.
   (4) Not vary by more than + 5 psi.
   (5) Not exceed twice the rated pressure of closed valves or hydrants included in the test section.
   (6) Not exceed the rated pressure of resilient-seated butterfly valves.

The contractor shall be responsible for providing and installing materials that will meet these test requirements.

C. Pressurization:

   (1) Slowly fill each valved section of pipe with water using a metered backflow protected assembly as provided by the Clarksville Water Department. After filling the line all valves are to remain closed until after testing to assure that water does not circulate back into the public system. Final connections to the existing water system are not to be made until all tests are complete.

   (2) Apply the specified test pressure, based on the elevation of the lowest point of the line or section under test and correct to the elevation of test gauge by means of a pump connected to the pipe in a manner satisfactory to the Owner.

D. Air Removal:

   (1) Before applying the specified test pressure expel air completely from the pipe, valves and hydrants. It is recommended that the lines remain pressurized for a minimum of 24 hours before testing in order for joints to tighten and pockets of air to dissolve in the water.

   (2) If permanent air vents are not located at all high points, install corporation cocks at such points to expel air as the line is filled with water.

   (3) After all the air has been expelled, close the corporation cocks and apply the test pressure.

   (4) At the conclusion of the pressure test, remove the corporation cocks and plug or leave in place at the discretion of the Owner.
E. Examination:

(1) Carefully examine all exposed pipe, fittings, valves, hydrants, and joints.

(2) Repair or replace any damaged or defective pipe, fittings, valves, or hydrants with sound material and repeat the test until the results are satisfactory to the Owner.

3.6 WATERLINE LEAKAGE TESTS

A. Concurrently conduct a leakage test with the pressure test.

B. Leakage defined: the quantity of water that must be supplied into the newly laid pipe to maintain the specified test pressure after the air in the pipeline has been expelled and the pipe has been filled with water.

C. Allowable leakage per hour:

The allowable leakage shall be no greater than as calculated in:

\[ L = SD (P)^{\frac{1}{2}} / 133,200 \]

Where \( L \) is allowable leakage in gallons/hour, \( S \) is the length of the pipe tested in feet, \( D \) is pipe diameter in inches, and \( P \) is the test pressure in psi.

Variation from Permissible Leakage. Should any test of pipe laid disclose leakage greater than that specified, the Contractor shall, at his own expense, locate and repair the defective joints until the leakage is within the specified allowance. Any visible leak should be corrected.

(1) When testing against closed metal-seated valves, an additional leakage per closed valve of 0.078 gal/hr/in. of nominal valve size shall be allowed.

(2) When hydrants are in the test section, test against the closed hydrant.

3.7 ACCEPTANCE OF INSTALLATION

A. If any test of pipe laid discloses leakage greater than that specified above, locate and repair the defective material until the leakage is within the specified allowance.

B. Repair all visible leaks regardless of the amount of leakage.
3.8 CLEANING AND DISINFECTION OF WATER LINES

A. Flush waterlines clean prior to disinfection.

B. Thoroughly disinfect waterlines prior to placing in service.

   (1) Use chlorine disinfecting agent applied to produce a 50 ppm dosage.
   (2) Allow water to escape from the ends of all lines to cause dispersion of the chlorine solution into all parts of the system.
   (3) Operate all valves and hydrants during the time disinfection is occurring.
   (4) Retain the chlorine solution in the lines for a period of 24 hours.
   (5) At the end of the 24 hour period, the residual chlorine must be a minimum of 25 ppm. Otherwise, repeat the disinfection procedure again.
   (6) Upon refilling the lines, collect a sample for bacteriological analysis. If the sample is acceptable, the lines may be connected to the system. Otherwise repeat the disinfection procedure until acceptable samples are obtained.

(7) The contractor will collect a water sample for microbial analysis. If the sample is acceptable, the lines may be connected to the system. Otherwise repeat the disinfection procedure until acceptable samples are obtained.

END OF SECTION 331000 – WATER DISTRIBUTION SYSTEMS
PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

This work shall include the placement of water and sewer lines and the minimum separation required.

PART 2 – PRODUCTS

Not used.

PART 3 – EXECUTION

3.1 PARALLEL INSTALLATION

A. Water mains shall be separated from sanitary sewer facilities a minimum of 10 feet, measured edge to edge.

B. When conditions exist that prevent a horizontal separation of 10 feet, closer installations may be made if:

1. The bottom of the water main is 18 inches above the top of the sanitary sewer facility.
2. The sanitary sewer facility is constructed of materials equivalent to water main standards and pressure tested to assure water tightness prior to backfilling.

3.2 CROSSINGS

A. Water mains shall be a minimum of 18 inches above the top of the sanitary sewer facility whenever possible.

B. When conditions exist that prevent vertical separation, the following methods shall be used for construction.

1. Sanitary Sewer facilities passing over or under water mains should be constructed of materials equivalent to water main standards and pressure tested to assure water tightness prior to backfilling.
2. Water mains passing under sanitary sewer facilities shall, in addition, be protected by providing:

   a. A vertical separation of at least 18 inches between the bottom of the sanitary sewer facility and the top of the water main.
   b. Adequate structural support for the sanitary sewer facility to prevent excessive deflection of joints, settling and breaking of the water main.

   c. That the length of water pipe be centered at the point of crossing so that the joints will be equidistant and as far as possible from the sewer.
3.3 SEWER FACILITIES

A. Do not install water or sanitary sewer facilities which pass through or contact each other.

END OF SECTION 33 11 13 – SEPARATION OF PIPE UTILITIES
PART 1 - GENERAL

1.1 WORK INCLUDED

Installation of sanitary sewerage systems.

1.2 RELATED WORK:

A. Section 31 00 00: Earthwork
B. Section 33 10 00: Water Distribution Systems

PART 2 - PRODUCTS

2.1 CONCRETE PIPE AND FITTINGS

A. Reinforced Concrete Sewer Pipe (RCP): conform to the permeability and hydrostatic requirements of ASTM C-443.

B. Non-reinforced Concrete Sewer Pipe: ASTM C-14, except that the minimum content of cement shall be 940 pounds (10 bags) per cubic yard with flexible gasket joints conforming to ASTM C-443.

2.2 POLYVINYL CHLORIDE PIPE AND FITTINGS

A. Manufactured from virgin, National Sanitation Foundation (NSF) approved resin conforming to ASTM D-1784.

B. Unless otherwise specified, all PVC gravity sewer pipe and fittings shall conform to ASTM D-3034 and have a Standard Dimension Ratio (SDR) of 35.

C. The gaskets used for joining PVC sewer pipe shall conform to ASTM F-477.

D. All PVC gravity sewer pipe shall be clearly marked with the manufacturer's name, nominal diameter, SDR, ASTM, D-3074, and NSF approval seal.

E. PVC force mains shall meet the requirements of ASTM D-2241 and shall meet the other requirements as specified herein for PVC water mains.
2.3 DUCTILE IRON PIPE AND FITTINGS

A. Pipe:

1. Manufactured in accordance with ANSI A-21.50 (AWWA C-I5I) and ANSI A-21.10 (AWWA C-I10).
2. A cement lining meeting the requirements of ANSI 21.4 (AWWA C-I04).
3. A minimum of 1 mil thick bitumastic coating on the outside surface.
4. Clearly mark with manufacturer's name, D.I. or ductile, weight, class or nominal thickness, and casting period.
5. Unless otherwise specified or shown on the Plans, ductile iron pipe shall be Class 50 for 200 psi working pressure.

B. Fittings:

1. Fittings 4" - 24": Pressure rated at 350 psi.
2. Fittings 30" - 36": Pressure rated at 250 psi.
3. Joints meeting the requirements of ANSI A-21.11 (AWWA C-I11).

2.4 CONCRETE MATERIALS

A. Class "A" for all pipe and structures. Class "B" for encasements and manhole foundations.

2.5 CASTINGS FOR FRAME AND COVERS

A. Gray iron, Class 30, unless otherwise specified, meeting AASHTO M-108. The standard for the City of Clarksville is Bouchard No. II50 or equal. A clear opening of 24 inches is required and covers must be interchangeable to be considered equal.

B. Cleaned and coated with bituminous paint that will produce an acceptable finish that is not affected by exposure to hot or cold weather.

C. Rings and covers for use on watertight manholes shall be machined to a smooth uniform bearing that will provide a water tight seal. Watertight manholes shall be the double cover type with rubber gaskets. Bouchard No. 1122 or approved equal which has a similar combined weight of frame and cover and has covers of similar dimensions to interchange with present City castings.
2.6 PRECAST MANHOLE

A. AASHTO M-199 SR or ASTM C-478.
B. Rubber booted openings shall be provided for the required number and size pipes and shall be marked to insure installation at proper locations.
C. Use pre-molded rubber or approved bituminous gaskets at all joints between sections in sanitary sewer manholes.

2.7 MANHOLE STEPS

A. ASTM C-478.
C. Aluminum Steps: fabricated from aluminum alloy 6061, T6.
D. 3/8" steel rod totally encapsulated in polypropylene plastic.
E. Manhole steps shall be corrosion resistant, free from sharp edges, burrs, or other projections which may be a safety hazard and shall be of sufficient strength to be live load of 300 pounds imposed at any point.
F. The minimum width of cleat shall be of 10 inches.
G. The legs and struts shall be of sufficient length for the cleat to project a minimum clear distance of 4" from the well when the step is securely imbedded in the manhole wall.
H. The top surface of the cleats shall be designed to prevent foot slippage.

2.8 PIPE ENTRANCE COUPLINGS FOR MANHOLES

A. For pipe diameters 12" and smaller: ASTM C-425.
B. Where flexible pipe is used, the rigid manhole entrance coupling shall be of asbestos cement with a confined rubber O-ring meeting ASTM C-428 and ASTM D1869.
C. Other specially designed flexible products such as "KOR-N-SEAL", or approved equal, may be approved where available and designed specifically for providing a water tight seal and bond between the pipe, gasket and concrete.
D. When making a main or service connection to an existing manhole or to any manhole for which a factory installed booted opening has not been provided, a hole shall be cut into the manhole with minimal damage to the structure. The pipe shall be provided with an asbestos cement entrance coupling or a tight fitting rubber gasket which will provide proper adhesion for grout and ensure a water tight connection to the manhole.

PART 3 - EXECUTION

3.1 PREPARATION

A. Prior to laying pipe, prepare suitable bedding.

B. Before placing pipe in the trench, field inspect for cracks or other defects; remove defective pipe from the construction site.

C. Swab the interior of the pipe to remove all undesirable material.

D. Prepare the bell and remove undesirable material from the gasket and gasket recess.

3.2 INSTALLING GRAVITY SANITARY SEWERS

A. Lay pipe true to the lines and grades from the grade and alignment stakes, or equally usable references.

(1) Where laser equipment is used, provide offset hubs at every manhole location for purposes of checking grade between sections.

(2) Where batter boards are used, furnish stakes at intervals of 50 feet along the route of the pipeline.

(3) Set stakes at such distance from centerline of excavations as is suitable for the excavating method and machinery used.

(4) Provide and use accurately set batter boards at each 50 foot interval in establishing the bottom invert of each pipe laid.

B. Accurately establish the centerline of each pipe using a string stretched between targets and a plumb line extended to the centerline of the pipe.

C. Carefully inspect all pipe and each fitting prior to its placement in the trench, and reject and remove any defective pipe or fitting from the job site.

D. Lay pipe progressively up grade, with bell upstream in such a manner as to form close, concentric joints with smooth bottom inverts. Joining of all pipe shall be in accordance with manufacturer's specifications.

E. Bed each pipe section in accordance with Section 02210 of the Clarksville Gas & Water Standard Specifications.
F. Unless otherwise specified, provide all gravity sewer lines with a minimum of 4 feet of cover in roadways and 3 feet of cover in open areas, unless ductile iron pipe or concrete encasement is used. Pipe protection may also be required in other areas subject to erosion, very heavy traffic, or along property lines where future fence posts could be anticipated.

G. Do not allow walking on completed pipelines until backfill has been placed to a depth of at least 6 inches above the crown of the pipe.

H. Keep the interior of the pipe free of all unneeded material, and upon completion of a section between any two manholes it shall be possible to view a complete circle of light when looking through the pipe.

I. When laying pipe ceases, close the open ends of the pipe with a suitable plug for preventing the entrance of foreign materials.

J. Couplings and adapters used for joining dissimilar gravity pipe materials, for repairing and rejoining sections of gravity sewer, and for connecting the first full joint of pipe to a short stub through a manhole wall shall meet the requirements of ASTM C-594-594.

K. All couplings and adapters for gravity sewer pipe shall be of rubber, plastic and metallic materials that will not be attached by municipal wastewaters or aggressive elements in the soil and conform to ASTM C-425, Section 5.

3.2.1 INSTALLING SEWER FORCE MAINS

A. Sewer force mains shall be installed in accordance with the specifications contained herein for the installation of water mains Section 02713. Particular care shall be taken to assure the line is maintained on a constant positive or negative grade.

B. At points on the line profile where a hump is necessary to change from a positive to a negative grade, an air relief or combination air/vacuum relief valve shall be installed as specified in Section 02713 with the exception that all relief assemblies shall be 2" nominal diameter unless specified on the plans as a larger diameter.

3.2.2 LEAKAGE TESTING OF FORCE MAINS

A. Testing of lines shall comply with the provisions listed below, or similar approved procedures which will insure equal or better results.
B. Pipelines of whatever material, when tested under a pressure of 50 psi in excess of normal working pressure of the pipe, measured at the lowest elevation of the pipe shall not show leakage exceeding the following values as prescribed by the latest revision of AWWA C600.

<table>
<thead>
<tr>
<th>Force Main</th>
<th>Test pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Size</td>
<td>150 psi</td>
</tr>
<tr>
<td>8-inch</td>
<td>0.75 gal./hour</td>
</tr>
<tr>
<td>6-inch</td>
<td>0.55 gal./hour</td>
</tr>
<tr>
<td>4-inch</td>
<td>0.37 gal./hour</td>
</tr>
</tbody>
</table>

C. The contractor shall furnish all gauges, meters, pumps, and other equipment required and shall maintain said equipment in condition for accurate testing as determined by the Owner's Inspector. Where practicable, pipelines shall be tested in lengths between line valves or plugs of not more than 3000 feet. Where leaks are visible at exposed joints and/or evident on the surface when joints are covered the pipe shall be rejoined and leakage minimized regardless of total leakage as shown by test.

D. Duration of test shall be not less than 2 hours where joints are exposed and not less than 8 hours where joints are covered. Lines which fail to meet the leakage requirements shall be repaired and retested until test requirements are met. All pipe, fittings, and other materials found to be defective under test shall be removed and replaced at the Contractor's expense.

3.2.3 IDENTIFYING TAPE:

A. The location of all non-metallic service laterals and force mains lines installed under these specifications shall be marked by the use of a continuous tape, two inches in width, made of polyethylene plastic with a metallic core. The tape shall be buried in the trench, above the pipe, not more than two feet below the surface. The tape shall be marked indelibly with the words "Sewer Main Below" or similar wording to warn unwary excavators.

B. CMCSS PVC utilities (less irrigation lines) should have a tracer wire located directly above the line and terminated on a metal device accessible from the surface without excavation.
3.3.1 BYPASS PUMPING

A. Where flow stoppage may be necessary and the flow is so great as to require, the Contractor shall bypass the sewage around the section or sections of line that are being repaired by plugging an existing upstream manhole. The pump and bypass lines shall be of adequate capacity and size to handle the flow.

UNDER NO CIRCUMSTANCES WILL THE DUMPING OF RAW SEWAGE ONTO PRIVATE PROPERTY, OR INTO STREAMS, STORM SEWERS OR IN CITY STREETS BE ALLOWED.

B. Except as may be approved by the Owner's Inspector at the end of each working day temporary connections shall be made so that overnight pumping is not required. Bypassing of sewage shall be considered a subsidiary obligation of the contract and no separate payment shall be made for this work.

3.3.2 INITIAL PROOF TESTING OF SANITARY SEWERS

A. It is the intent to specify a "test as you go" procedure in order to establish confidence in the installation and avoid the unnecessary delay of final acceptance.

B. Before a reach of pipeline is approved, successfully proof test that reach for grade, alignment, cleanliness, and leakage.

C. In the event that four or more reaches fail to satisfactorily pass proof testing procedures, cease pipe laying until deficiencies are identified and corrected.

D. The basis for grade, alignment and cleanliness testing will be visual inspection. Leakage testing will be by means of low pressure air as specified hereinafter.

E. Proof test flexible pipeline installation for deflection by pulling a "go-no-go" test mandrel through the line after the initial backfill is complete to avoid unnecessary digups.

3.4 FINAL TESTING

A. Before the job is accepted and before any house services are connected, a final testing procedure is to be followed.

B. Perform a visual inspection when groundwater levels are above the pipeline if possible. All visible leaks shall be repaired.

C. If there is evidence of infiltration, make measurement with suitable pipe weirs:
(1) If the flow through the lower most manhole of a continuous section of sewer does not exceed 200 gallons day/inch/mile of pipeline and the groundwater level is representative of the highest annual level, the entire continuous section shall be approved for leakage.

(2) The leakage test will be conducted with all lines connected (including service lines).

(3) If the apparent infiltration rate exceeds 200 gallon/day/inch/mile, then take additional weir measurements to isolate those sections leaking.

(4) Any single reach of pipeline which exhibits an apparent infiltration rate in excess of 200 gallon/day/inch/mile will not be accepted and all leaks will be located and corrected.

D. If it is not practical to wait for groundwater levels that are representative of the highest annual level, the contractor may request approval on the basis of a low pressure air exfiltration (or other approved exfiltration) test.

(1) Such test, if approved by the Engineer, will be conducted in accordance with ASTM C-828.

(2) When an exfiltration test is used as a substitute for infiltration testing, correct all conditions what are potential sources of infiltration.

E. DEFLECTION TESTING:

(1) Lines constructed of flexible pipe shall be tested for deflection. The testing shall commence not less than 24 hours after backfilling and be accomplished as follows:

(2) Flexible pipe shall pass a vertical floating pin type go-no-go mandrel (or effective 8 arm equivalent) sized to 95% of the pipe diameter of the actual pipe used with the pipe in place and covered.

With 15% of pipe tested, if 100% passes 5% deflection, then no other work is needed. If the first 15% fails then another 15% shall be tested. If second 15% fails as first 15% then all pipe shall be tested. Selection of portion of line to be tested shall be selected by the Engineer and shall be, in his judgment, the worst portion of the installation.
3.5 LOW PRESSURE AIR EXFILTRATION TEST

A. Calculate the pressure drop as the number of minutes for the air pressure to drop from a stabilized pressure of 3-1/2 to 2-1/2 PSIG.

B. Length of section under test not to exceed 500 feet.

TIME INTERVAL SCHEDULE FOR AIR TEST

<table>
<thead>
<tr>
<th>Diameter (inches)</th>
<th>Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>340</td>
</tr>
<tr>
<td>10</td>
<td>425</td>
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</tr>
<tr>
<td>21</td>
<td>892</td>
</tr>
<tr>
<td>24</td>
<td>1020</td>
</tr>
</tbody>
</table>

3.6 SEWER MANHOLES - TESTING AND GENERAL

A. TESTING - New manholes are to be vacuum tested for tightness after all line connections are made and the casting is in place, but before backfilling. All entering lines should be plugged and blocked. The casting opening shall be sealed with an appropriate testing/sealing device and a vacuum of 10" mercury (5 PSIG) pulled on the manhole, using the procedure specified by the test assembly manufactured. (DO NOT PUT A POSITIVE PRESSURE ON THE MANHOLE). If the vacuum has not dropped more than 1" mercury (0.5 PSIG) at the end of one minute, the test is passed. If not, repair any leaks and repeat tests until results are acceptable per above standards.

B. Unless otherwise specified, all manholes shall have an inside diameter of not less than 4 feet and a vertical wall height of not less than 2.5 feet.

C. The clear opening in the manhole shall be not less than 2.0 feet.

D. Depth of the manhole shall be the vertical distance from the lowest invert in the manhole to the top of the ring.

E. The first section of pipe entering and leaving the manhole shall be ductile iron or PVC.

   (1) Lay these sections of pipe in a bed of Class I material

   (2) Use non-shrink grout on pipe or couplings through manhole walls. Fill all recesses around pipe entrance with grout to match the surface profile of the surrounding wall and invert.
F. All pipe connections with the manhole shall be by rubber boot cast into manhole.

(l) When field change requires revised entrance into manhole, secure the pipe to the manhole wall by means of an asbestos concrete manhole coupling, with O-ring assembly, or an approved gasket assembly designed to provide a water tight seal between the pipe exterior and grout.

G. Backfill manholes with the same material used for backfilling pipelines.

3.7 STANDARD PRECAST CONCRETE MANHOLES

A. ASTM C478.

B. The base of the manhole shall be Class B concrete not less than 8" in depth with inverts not less than 4" in depth.

C. Shape manhole inverts from Class B concrete to be smooth, accurately shaped, and in accordance with the Plans.

D. Inlets and outlets from each manhole shall be finished smooth and flush with the sides of the manhole walls so as not to obstruct the flow of liquid through the manhole.

E. When possible, the base of the manhole shall be poured on dry, consolidated and undisturbed soil.

F. When wet or unconsolidated material occurs or when over-excavation of the base occurs, provide a subbase with a minimum of 12" of Class I, granular material, well compacted with mechanical tamping equipment.

G. When completed, the manhole shall be free from channel obstructions and leakage.

H. Seal joints between sections with a rubber O-ring, "RAM-NEK" gasket, or approved equal.

3.8 "CAST-IN-PLACE" CONCRETE MANHOLES

A. Manholes shall conform to the dimensions outlined on the Plans.

B. The vertical forms, wall spacers, steps and placing cone must be carefully positioned and firmly clamped in place before any placement is made.

C. The wall spacers must be located 90 degrees from each other.

D. Use Class "A" concrete with a maximum slump of 4".
E. First place approximately 1/2 yard of concrete evenly around the walls and vibrate until there is a minimum slope of 60 degrees from the bottom of the forms to the bearing surface both inside and outside of the manhole.

F. When this is complete and before additional concrete is added, vibrate the concrete on each side of each pipe.

G. Deposit additional concrete in evenly distributed layers of about 18" with each layer vibrated to bond it to the preceding layer.

H. Raise the wall spacers as the placements are made, with the area from which the spacer is withdrawn being carefully vibrated.

I. Excessive vibration is to be avoided.

J. A maximum of 2% Calcium Chloride may be added to the concrete, at the Contractor's option, to speed the set.

K. Remove the forms as soon as the concrete has sufficiently set, but not within 6 hours of pouring and not without approval.

L. Excessive honeycombs will be cause for rejection of the manhole. Honeycombs and other imperfections shall be mortared as soon as possible after form removal so that a proper bond will take place.

M. Form marks and offsets of up to 1" will be permitted on the outside surface of the manhole.

N. Form marks and offsets up to 1/2" will be permitted inside of the manhole.

O. All offsets on the inside surface of the manhole will be smoothed and plastered so there is no projection or irregularity capable of scratching a worker or catching and holding water or solid materials.

P. Honeycomb will be plastered with mortar, consisting of three parts of masonry sand to one part Portland cement, immediately upon removal of the forms.

Q. Water tight connections to pipes incorporated into cast in place manholes or bases shall be insured by installing a tight fitting rubber gasket or asbestos cement manhole coupling on pipes where the pipe end is accessible. When the concrete is to be cast around an existing active pipe, "RAM-NEK" or equal gasket or water proof packing material is to be tightly wound around the pipe and incorporated into the poured concrete.

3.9 MANHOLE STEPS

A. Set manhole steps at intervals of 15 inches along the wall of the manhole.

B. The treads of the steps shall be free from mortar or other material when the manhole is completed.
C. In precast manholes, the holes left to receive the steps shall be mortared smooth following placement of the steps.

3.10 MANHOLE RINGS AND COVERS

A. Concrete and/or brick leveling courses shall be used as necessary to assure the cover meets the final grade and cross-sections of improved areas.

B. A full circle of "RAM-NEK" or equal bitumastic seal shall be placed between the manhole ring frame and the masonry portion of the manhole to assure water tightness. The frame shall be further secured to the manhole by the use of mortar or grout placed from the outside edge of the masonry structure to a point approximately 1" below the top of the casting.

C. The bearing surfaces between cast rings and covers shall be machined, fitted together, and match marked to prevent rocking.

D. All castings shall be of the types, dimensions, and weights as shown on the Plans and shall be free of faults, cracks, blow-holes, or other defects.

3.11 DROP MANHOLE ASSEMBLIES

A. Drop manhole assemblies shall be constructed as outlined on the plans.

B. The material used in the drop pipe construction shall be PVC, ductile iron and Class "D" concrete.

3.12 SEWER SERVICE ASSEMBLIES

A. Where shown on the plans or located in the field, install fittings for individual service assemblies.

(1) The standard collector tap shall consist of a tee or wye connected with a 4 inch diameter branch.

(2) Use vertical risers when the depth of the collector line is greater than 8 feet or when their use will facilitate connection of individual services.

(3) Plug the ends of tee branches not to be used immediately with stoppers of the same material and joints used on the collector lines.

B. Where shown on the Plans or located in the field, install collector saddles by attaching to the sewer main by stainless steel bands secured by 2 bronze or stainless steel bolts, with a minimum diameter of 3/8" or by using an epoxy bond.
C. Service pipe shall be a minimum 4" diameter and shall be installed as shown in the Plans.

   (1) Plug the ends of service pipe and cover the same as for collectors and interceptors (where possible).

   (2) The minimum grade on service pipes shall be 1% or 1/8" per foot.

   (3) Metallic detector tape shall be installed above and parallel with all non metallic service lines as specified herein for force mains.

   (4) Contractor is to install and reconnect all services encountered during construction to a point approximately 3 feet onto the customer’s property or ten (10) feet past the top of bank of the drainage path. If main is on the customer’s property a three (3) foot section shall still be installed. Pipe shall be cut as necessary to maintain above standards unless additional footage is required for chimney risers from deep cuts.

END OF SECTION 333000 – SANITARY SEWERAGE SYSTEMS
PART 1 – GENERAL

1.1 WORK INCLUDED

A. Provide all labor, materials, equipment and services required to furnish and install the storm sewer collection system as indicated on the plans and in the Contract Documents.

B. Sewer collection system work includes, but is not limited to the following:
   1. Storm sewer conduits.
   2. Catch basins, area drains, frames, and gratings.

1.2 RELATED SECTIONS

A. Section 31 00 00 – EARTHWORK

1.3 REFERENCE DOCUMENTS

A. ASTM STANDARDS:

   • ASTM C 76, Reinforced Concrete Culvert, Storm Drain and Sewer Pipe
   • ASTM C 443, Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
   • ASTM D 2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
   • ASTM D 2487, Test Method for Classification of Soils for Engineering Purposes
   • ASTM D 3350, Standard Specification for Polyethylene Plastic Pipe and Fittings Materials
   • ASTM F 477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
   • ASTM F 913, Standard Specification for Thermoplastic Elastomeric Seals (Gaskets) for Joining Plastic Pipe
   • ASTM F 1336, Standard for PVC Gasketed Sewer Fittings

1.4 SUBMITTALS

A. General: Submit the following according to Conditions of the Contract:

   1. Product data for materials and items, including type of conduit, joint material, etc.

   2. Material certificates shall be signed by manufacturer and Contractor, certifying that each material item complies with or exceeds specified requirements.
NOTE 1 - When polyethylene pipe is to be used in locations where the ends are exposed, the exposed ends shall be protected from sunlight due to the deteriorating effect of ultraviolet radiation.

NOTE 2 – Storm water outfalls shall have protection grates.

PART 2 – PRODUCTS

A. Conduit Materials:
   1. Polyethylene pipe and fittings shall meet the requirements of ASTM D 3350.
   2. Reinforced Concrete Pipe (RCP) shall meet the requirements of ASTM C76, Class as indicated.

B. Bedding Material.
   1. Material for bedding for pipe conduits shall be hard durable particles or fragments of stone, slag, gravel, or chert, together with such material conforming to classifications in ASTM D 2487, for the purposes of use as backfill specified in ASTM D 2321.
   2. The gradation of the bedding for pipe conduits shall be Class 1A Manufactured Aggregate, open-graded, clean, and conforming to ASTM D 2487.

C. Backfill Material.
   1. Material for backfill around polyethylene pipe shall meet the requirements of ATSM D 2321.

D. Joint Materials.
   1. Joint mortar shall consist of one-part Portland cement and two parts sand with water necessary to obtain the required consistency.
   2. Rubber gaskets shall conform to the requirements of ASTM C443.

D. Elastomeric Seal:
   1. Material used for elastomeric seal in push-on joints shall meet the requirements of either ASTM F 477 or F 913.
   2. Lubricant, if required, shall be suitable for lubricating the parts of the joints in the assembly. The lubricant shall have no deteriorating effects on the gasket and pipe materials.
PART 3 – EXECUTION

3.1 RECEIVING AND UNLOADING

A. The pipe is designed to withstand normal field handling and can be easily unloaded by hand or with equipment. To avoid damage the pipe should not be dropped. Additionally, tie down straps or bands should not be removed until the pipe has been secured to prevent rolling or dropping the pipe.

B. Handling should be accomplished by hand, lifting tongs or nylon slings. When using slings, two pick points are recommended.

3.2 INSTALLATION

A. 1. The width of the trench shall be ample to allow the pipe to be laid and jointed properly and to allow the bedding and haunching to be placed and compacted to adequately support the pipe. The trench sides shall be kept as nearly vertical as possible.

2. Unsuitable foundations must be stabilized at the Designer’s direction. Ledge rock, boulders, and large stones shall be removed to provide a minimum clearance of 4 inches below and on each side of all pipe(s). Unsuitable or unstable foundations may be undercut and replaced with a suitable bedding material, placed in 6” lifts.

3. Other methods of stabilization, such as geotextile, may be appropriate based on the Designer’s judgment. Excavate the pipe trench to be sufficient to permit satisfactory jointing of the pipe and thorough tamping of the bedding material under and around the pipe.

B. 1. Stable and uniform bedding shall be provided for the pipe and any protruding features of its joints and/or fittings. Classes I, II, or III, as described in ASTM D 2321, shall be used and carefully compacted for all rigid pipe provided the proper strength pipe is used with the specified bedding to support the anticipated load, based on the type soil encountered and potential ground water conditions.

2. Proper haunching provides a major portion of the pipe’s strength and stability. Care must be exercised to insure placement and compaction of the embedment material in the haunches. Haunching materials may be Class I, II, or III and shall be placed and compacted in 6-inch maximum lifts, compacted to 90 percent standard proctor density.

3. All water entering the excavations or other parts of the work shall be removed until all the work has been completed. Excessive groundwater hinders proper placement and compaction of bedding and backfill. Corrugated Polyethylene Pipe will float in standing water; therefore, it is imperative that a dry trench be provided.
C. Lay conduit beginning at low point of a system, true to grades and alignment indicated with unbroken continuity of invert.

D. Bell or groove ends of rigid pipe and outside circumferential laps of flexible pipe shall be placed facing upstream.

E. Install gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements.

F. Cleaning Conduit: Clear interior of conduit of dirt and other superfluous material as work progresses.

G. Place plugs in ends of uncompleted conduit at end of day or whenever work stops.

H. Joint Assembly: Split couplers are installed by laying the adjoining sections of pipe in the open split coupler and wrapping the coupler around the pipe. Nylon ties may then be fed through the holes in the end of the coupler to secure the coupler to the pipe. The pipe and the inside of the coupler should be clean and free of dirt prior to securing the coupler. Bell and spigot or bell-bell couplers incorporating an elastomeric rubber gasket are either an in-line bell, a welded bell, or a bell-bell. These couplers are easily installed by the following procedure which will insure the specified performance.

1. Thoroughly clean the bell and spigot ends, making sure they are free of mud and grit. Remove the protective shrink-wrap from the gasket. If the gasket has been removed, make sure the gasket seat is clean and reinstall the gasket by stretching it over the pipe and nesting it in the seat. Gaskets should be installed with the marking facing the coupler.

2. Remove shipping collars (where provided) prior to lowering the pipe in the trench. Properly dispose of shipping collars outside the pipe trench. Do not install pipe with shipping collars on the pipe and do not dispose of shipping collars in the trench.

4. Lubricant is supplied for gasketed joint installation in either buckets or spray lubricant. The lubricant should be liberally applied to both the bell and spigot ends of the pipe. Care should be taken to ensure lubricant is applied to the chamfered leading edge of the bell.
4. Align the pipe and push the spigot home on grade. Joints shall be installed with bells facing upstream for proper installation. Generally, pipes should be laid starting at the downstream end and working upstream. Small diameter pipe (below 24") can usually be installed by pushing the joint home by hand. When pushing the joint home, make sure bedding material is not pulled into the bell by the spigot. Material such as small stones and sand pulled into the bell as the pipe is joined can cause leaks.

I. Pipe shall be inspected before any backfill is placed. Any pipe found to be out of alignment, unduly settled, or damaged shall be taken up and re-laid or replaced at the Contractor's expense.

J. The trench shall be backfilled with suitable material removed from excavation or borrow. Debris, frozen material, large clods or stones, organic matter, or other unstable materials shall not be used for final backfill within 2 feet of the top of the pipe. Bedding material shall be placed along each side of the pipe in layers not to exceed six (6) inches in loose depth. Each layer shall be moistened or dried, if necessary, to near optimum moisture content and thoroughly compacted with mechanical tampers.

K. Placement of final backfill shall be in accordance with Specification Section 310000 – Earthwork.

3.3 INTERIOR INSPECTION

A. Inspect conduit to determine whether line displacement or other damage has occurred.

B. Make inspections after lines between structures have been installed and approximately two (2) feet of backfill are in place and at completion of project.

C. If inspection indicates poor alignment, debris, displaced pipe, infiltration or other defects correct such defects to satisfaction of Designer.

3.4 JOINTS and INFILTRATION

A. Storm sewer joints shall minimize infiltration and prevent the entrance of roots throughout the life of the system.

B. Service connections to the storm sewer main shall be water tight and not protrude into the sewer. If a saddle type connection is used, it shall be a device designed to join with the types of pipe which are to be connected. All materials used to make service connections shall be compatible with each other and with the pipe materials to be joined and shall be corrosion proof.
3.5 TAP CONNECTIONS

Make connections to existing conduits and underground structures so that finished work will conform as nearly as practicable to requirements specified for new work.

3.6 BACKFILLING

Conduct backfill operations of open-cut trenches closely following laying, jointing and bedding of pipe, and after initial inspection and testing are completed.

END OF SECTION 33 40 00 – STORM SEWERS
PART 1 – GENERAL

1.1 WORK INCLUDED

A. PVC surface drainage inlets shall include the drain basin type as indicated on the contract drawing and referenced within the contract specifications. Surface drainage inlets shall be manufactured by Nyloplast, a division of Advanced Drainage Systems, Inc., or prior approved equal.

B. Provide all labor, materials, equipment, and services required to furnish and install the engineered surface drainage products.

1.2 REFERENCE DOCUMENTS

A. ASTM Standards:
   - ASTM A 48-83, Standard for Gray Iron Castings
   - ASTM A 536, Standard for Ductile Iron Back-up Flanges
   - ASTM D 2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
   - ASTM D 3034, Standard for Sewer PVC Pipe and Fittings
   - ASTM D 3212, Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
   - ASTM F 1336, Standard for PVC Gasketed Sewer Fittings

NOTE 1 – When polyethylene pipe is to be used in locations where the ends may be exposed, the exposed parts shall be protected against combustibility and against deteriorating effects of prolonged exposure to ultraviolet radiation.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Drain basins shall be manufactured from PVC pipe stock, utilizing a thermo-molding process to reform the pipe stock to the specified configuration. The drainage pipe connection stubs shall be manufactured from PVC pipe stock and formed to provide a watertight connection with the specified pipe system. This joint tightness shall conform to ASTM D3212. The pipe bell spigot shall be joined to the main body of the drain basin or catch basin. The pipe stock used to manufacture the main body and pipe stubs of the surface drainage inlets shall meet the mechanical property requirements for fabricated fittings as described by ASTM D3034 and ASTM F1336.

B. Grates for all surface drainage inlets shall be ductile iron grates for sizes 8", 10", 12", 15", 18", 24" and 30" (12" and 15" frames are cast iron) shall be made specifically for each basin so as to provide a round bottom flange that closely matches the diameter of the surface drainage inlet. Grates for drain basins shall be capable of supporting H-25-wheel loading for heavy-duty traffic or H-10 loading for pedestrian traffic. 12" and 15" grates will be hinged to the frame using pins. Metal used in the manufacture of the castings shall conform to ASTM A536 grade 70-50-05 for ductile iron and
ASTM A-48-83 class 30B for 12” and 15” cast iron frames. Grates shall be provided painted black.

C. Polyethylene pipe and fittings shall be in accordance with ASTM D 3350.

PART 3 – EXECUTION

3.1 SURFACE DRAINAGE INLET

The specified PVC surface drainage inlet shall be installed using conventional flexible pipe backfill materials and procedures.

3.2 BACKFILL MATERIAL

Backfill material shall be crushed stone or other granular material meeting the requirements of class 1 or 2 material as defined in ASTM D2321. The surface drainage inlets shall be bedded and back-filled uniformly in accordance with ASTM D2321.

3.3 DRAIN BASIN BODY

The drain basin body will be cut at the time of the final grade so as to maintain a one piece, leak proof structure. No brick, stone or concrete block will be used to set the grate to the final grade height. For H-25 Load rated installations, an 8” to 10” thick concrete ring will be poured under the grate and frame as recommended by details provided from the manufacturer.

END OF SECTION 33 44 13 – ENGINEERED SURFACE DRAINAGE PRODUCTS